Notebook, N-88-06-10

This notebook, which covers the period June-August 1888, is a continuation of N-88-06-06. It contains transcriptions by Arthur E. Kennelly of material from the rough record books used by experimenters in the Galvanometer Room. Included are notes, drawings, tables, and calculations regarding batteries, non-magnetic watches, photometers, condensers, electric meters, and electrocution experiments. Among the experimenters whose work appears in this book are F. P. Bergh, E. C. Boynton, Alex W. Brigham, and Johannes H. Cuntz. The front cover is labeled "Record Book No 4." The back cover is labeled "509." The spine is labeled "53." Attached to the inside back cover is an index. The book contains 89 numbered pages. Some pages were removed before the book was paginated.

The index has been filmed first. Oversize graphs, formerly pasted onto pages 44, 50, 51, 60, 62, and 89, have been filmed at the end of the book at a reduction ratio of 18:1.

xE172

N-88-06-10

Record Book
of
Observations, Calculations, and
Data
Edison Laboratory
Galvanometer Building

Resumé of particulars of Primary Battery Test previous to making Report upon them.

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3 — 2-cup Brewsort-Robert Zinc Carbon cells were received at the laboratory on the 10th June. 88. Their price @ per invoice was $12.50 each and the solution supplied with them, apparently a bicromate of potash solution, was charged at 20 ct per gall. (10% discount was allowed on these prices)

These cells were stated to give a current of 4 ampires for several hours or 6 6 8 ampires for a few mins. at a time. Mr Meadowcroft said that a capacity of 500 ampire-hours was claimed for them, vide his letter of the 10th May.

The cells were set up according to directions on the 14th June with 1½ gallons of solution in the outer cell and water with salt added to it was poured into the porous cells round the zincs. The total amount of solution in each complete cell was thus about 10,000 c.c.

The zinc plates are about 35.6 × 15.1 × 0.18 are two to each complete cell and weigh about 1815 grammes each single cell exposing about 2150 sq. cms. of ~~plate~~ surface. and of this some 1850 is active in solution. The carbon plates are 3 in number weigh about 900 grammes, dimension 40 × 17.4 × 0.33. The surface of each plate is about 1400 sq. cms. and the active surface of the three together is about 1700 sq. cms excluding the two outside surfaces.

The three cells were set to work at 8.45 on the 15th June through a coil of stranded platinoid wire 4 wires each 0.084 cms diam. and offering together 0.5 ω.

The EMF commenced at 2.1 volts
" " int. res " " 0.06 ω
and " current " " 3.8 amps.

No change was made in the conditions during the test beyond adding water to the zinc cells as the liquid fell in them.

The test lasted for 165 hours at the end of that time the
EMF was about 0.45 volt
Int. Res. " " 0.06 ω
Current " " 0.6 amp

The energy developed by no 1 cell was 2,690,000 Joules
of which % = 2,512,000.
was externally evolved.
The quantity of electricity delivered 1,538,000 Coulombs
The zinc theoretically consumed to supply this
observed current was 518 grammes
The actual loss of zinc was 1303
representing a waste of % = 785

The energy developed by no 2 cell was 2,066,000 J.
of which % = 1,772,000
was externally evolved.
The quantity delivered was 1,315,000 C.
for which the zinc consumed should be 443 grs.
and actually was 516.
representing a waste of % = 73

The energy developed by no 3 cell was 2,091,000 J
of which % = 1,798,000.
was externally evolved
The quantity delivered was 1,303,000 C
for which the zinc consumed should be 439 grs.
and was actually 516
representing a waste of % = 74.

This is shown in the following scheme.

Cell No.	Coulombs delivered	Joules Energy Externally	Joules Internally	Total Joules	Zinc Theory Grms	Thousandth Part Expected	Actual Loss of Zinc	% Waste
1	1,538,000	2,512,000	178,000	2,690,000	432	518	1303	142
2	1,315,000	1,772,000	294,000	2,066,000	351	443	516	142
3	1,303,000	1,798,000	293,000	2,091,000	440	439	516	149
Mean	1,385,000	2,027,000	255,000	2,282,000				

The mean delivery of useful energy was thus 2,027,000 Joules or 1,494,000 ft. lbs:
the maximum 2,512,000 - 1,852,000 - -
- minimum. 1,772,000 - 1,306,000 - -

The rate of doing external work was at the outset (7.25 m) 8.3 Watts for cell no 1 at 0.011 Hot plate alle 6 Hot 90
6.15 - - - 2 0.008 121 -
6.35 - - - 3 0.0085 1175 -

The full powers of the cells may be said to have been as follows.
No 1. 7.0 Watts or over up to the 75th hour
- 2 5.0 - - - - - 50th -
- 3 5.0 - - - - - 60th -

The mean current for the 1st 75 hours of cell no 1 was 3.86 amperes a capacity of 290 amp.
- - - 2 - 2.59 - - in all - - - 427 - -
The mean current of #2 was 2.21 - - - - - 365 - -
- - - - #3 - 2.19 - - - - - 362 - -

The cells were taken down and put out of use until the 9th July 1888. The zinc plates were then amalgamated and weighed. There was found to be solution enough for ~~for~~ only two cells as although the third was run on half solution, it is left out of consideration. The ~~to~~ cells were set to work at 15.30 through 0.5 m as before

The trial lasted for 170 hours with the following results:—

Cell No.	Gallons delivered	Energy delivered				Zinc Consumed			Power at cell terminals	Volts from Curve	Volts per cell
		Ent:	Int.	Total	%	Theoretical	Actual	% Theoret.			
1	1,656,000	2,518,000	376,000	2,894,000	87	557.5	607	89%	6.15	5.4 volts	12.1
3	1,637,500	2,465,000	400,000	2,865,000	86	557.	622	12.9	5.78	5.8 volts	12.9
Mean	1,647,000	2,492,000	388,000	2,880,000	86						

The mean current for the ~~whole~~ period was (#1) 2.79 amperes a mean copy of 460 amp. hours.
(#2) 2.68 " " " " 455 "

The improved performance of the cells on the second occasion was supposed to be due to the amalgamation of the zinc plates.

About 120 cells go to a H.P. at 4 amperes per cell on this outlet.
For steady work 150 would have to be allowed. The duration of the cells might be perhaps 120 hours continuously. This would mean $\frac{150 \times 1\frac{1}{2}}{120}$ or 1.9 gallons of solution per hour also

$$\frac{3.5 \times 150 \times 1.1}{370} \text{ lbs. of Zn per H.P.}$$
$$= 1.56 \text{ lbs}$$

1.9 gallons of sol: @ 20 cts =	0.38
1.56 lbs of zinc - @ 7 cts	.11
Cost of material per H.P. hour	0.49

Three Mason-Wood cells reached the laboratory on the 2nd July but as part of them were found broken it was not till the 8th July that the materials were complete.

These are zinc-carbon two-fluid cells the outer jar being earthenware, and the two zincs being in the outer cell, one on each side of the porous pots with the carbons double in it.

The cells were made up according to the instructions received – namely sulphuric acid + water 5% in the outer cells and the special solution apparently a bicarbonate of potash solution poured into the porous pots to the extent of about 2 quarts.

The zinc plates were amalgamated. Their dimensions being 33 X 15·4 X 0·5 exposing a surface of about 1000 sq. cms. each of which only about 600 sq. cms. are exposed to the liquid, or about 1200 in all. The outer cells have sloping sides but the mean dimensions are 18 wide x 25 long X 31 deep, inside measurement, and they hold about 10,000 c.c. of solution under ordinary circumstances.

The weight of the zincs is about 5lb or 2300 grammes each. The carbons are double each has a surface on one face of 15×31 = 465 sq. cms. of which some 360 are exposed in liquid making an active surface of some 750 sq. cms.

The price of the cells is @ per invoice $11.20 each. The solution is 75 ct a gallon, and half a gallon is used as a charge.

The cells were set to work with the Brevoort Robert at 15.30 on 0.5 platinoid strand of the filey. Their

EMF at starting was 2.09 volts
I.R 0.07 ω
Current 3.7 amp

The test lasted for 170 hours. At the end of which time the EMF was 0.5 volts
I.R. 0.5 ω
Current 0.5 amperes.

The plates were then weighed and the output found to be @ follows:—

Cell	Quantity delivered	Energy delivered				Time consumed			
	Coulomb	Externally	Internally	Total	% output	Theoretic	Actual	Waste	Cost
#1	604,600	495,300	181,200	676,500		203.5	514.6	311.1	61.4%
#2	734,800	730,000	202,500	932,500		247.4	521.6	274.2	
#3	711,000	705,700	257,700	963,400		239.4	521.6	281.6	
Mean	683,000	642,000	213,000	857,000					
of tests	723,000	718,000	230,000	948,000					

It should be stated that the carbon of no 1 cell was a double one with a consequently double head and this was set in position touching both zincs for two hours before it was noticed. This may have short-circuited that cell for two hours and if so it will account for the reduced output and excessive waste of zinc. Our figures therefore are based on nos. 2 + 3.

For the 1st 5 hours

No 2 had an output of 5.8 Watts or 129 to the HP.
3 . . . . 5.4 . . 138 . . .

The mean current from No 2 was 1.24 amp.
a capacity of 210 ampere hours.
The mean current from No 3 was 1.20 amps
a capacity of 204 ampere hours.

At fifty hours the output was 0.7 Watts from No 1
0.6 Watts . . 2
Meaning more than 1000 to the HP

To supply a H.P. for 24 hours.
after the 25 hour both cells gave 2.44 Watts or 168 HP
so that 150 cells would be required.
The mean current during that hour would be 3.25 amp
The consumption of zinc would be $\frac{3.25 \times 150 \times 2}{370}$ = 0.17
= 2.44 lbs. per HP. hour @ 7 cts = 1.12
Solution say half exhausted = $\frac{1}{2} \times 2.44 \times \frac{150}{2.5} \times 0.75$
Cost of Material per H.P. hour. 1.29
neglecting H2SO4

Made up a transformer as follows –

Upon a coil of iron wire (no 26) 0·018" about 20 cm meni diam: 20 oz of no 23 wire silk covered was wound and this layer after being taped with india rubber was covered with 12 oz of no 30 silk covered wire

The Res. of the copper wire was 10·5 ω
that - - - fine - - 106 ω.

No 23 wire ·025" has 60·5 feet per ω = 635 feet.
- 30 - ·012" - 114 - - - 1184 -

Subsequently increased the 2nd wire by 5 oz: and to a resistance of 151·2 ω @ 85°
no 30 BWG ·0·012" = 2100 feet.

alteration of Rate

	122 20
1.0	0 00
1.0	0 5
.25	0 7.5
.75	3 25
1.5	8 5
.5	1.0
1.75	5 7.5
2.5	8 25
2.5	1.0
8.5	2.0
6.0	2.0
4.0	1.0
6.25	1.5
1.0	0 25
9.25	2.75
18.0	3.0
4.00	0.25
0.5	1.75
6.25	7.0
1.0	2.8
2.25	0.75
3.5	2.25
.75	2.5
2.0	3.25
3.75	2.5
1.50	2.0
.25	186 2.5
1.75	2.0
1.0	58
.75	
1.0	
10.0	
8.0	
6.5	
3.0	
122 6 0	

67 | 162 / 184 / 260 | 12

58 186 25 321
1225
65

Watch #1 Paillard $51.872 $ 67.50 .. 3.21

Date	Hour	Error	Rate	Temp	Rate for 24 hrs	Date	Hour	Error	Rate	Temp	Rate for 24 hrs
28.6.	13.20	-17		66°		3.8.88	8.15	+80	+8½	80°	
29.6	8.40	-20	-3	66°	-3¾	4.8.88	8.15	+88½	+8½	80°	
30.6	8.40	-22¾	-2¾	65°		5.8.88	9.30	+88½	0	80°	
1.7	10.00	-24½	-1¾	67°		6.8.88	9.15	+94	+5½	80°	+5¾
2.7	11.00	-26	-1½	69°		7.8.88	8.28	+103	+9	80°	
3.7	8.20	-28	-2	70°	-2¼	8.8.88	8.20	+103½	+½	76°	
4.7	8.30	-28¾	-¾	70°		9.8.88	8.15	+105	+1½	75°	
5.7	8.40	-29	-¼	76°		10.8.88	9.15	-22½	+127½	78°	
6.7	8.25	-27½	+1½	76°		11.8.88	8.10	+13	+135½	76°	
7.7	8.30	-33½	-6	78°		12.8.88	10.00	+21½	+8½	80°	+7¼
8.7	9.50	-37	-3½	95°		13.8.88	8.15	+28	+6½	78°	+7
9.7	8.15	-32	+5	100°		14.8.88	8.20	+34	+6	80°	
10.7	8.10	-33	-1	105°		15.8.88	8.20	+42	+8	80°	
11.7	8.50	-39	+3	76°		16.8.88	8.20	+52	+10	80°	
12.7	8.25	-33½	-3½	49°		17.8.88	8.25	+63	+11	82°	
13.7	9.05	-35½	-2½	49°			8.35	+82	+19		~~+15~~
14.7	8.15	-47	-11½	49°		18.8.88	8.20	+92	+10	80°	+10½
15.7	10.00	-40	+7	100°	+6½	19.8.88	10.20	+103	+11	82°	+10½
16.7	8.20	-34½	+5½	100°	+10¼	20.8.88	8.20	+110	+7	82°	+7¾
17.7	8.20	-21	+9½	100°			12.05	-172	-282		~~+14½~~
18.7	8.15	-12	+9	100°		21.8.88	8.20	-163	+9	80°	+10¾
19.7	8.10	-2	+10	100°			8.25	-152	+9	78°	
20.7	8.20	+10½	+12½	100°		22.8.88	11.35	-152	+3	76°	
21.7	8.25	+10	+0½	78°			8.20	-142	+10	75°	
22.7	10.05	+27	+8	78°	+8½	23.8.88	10.15	-142	+4	76°	+4½
23.7	8.25	+33	+6	78°	+6½		10.25	-140	+0		+8¾
24.7	8.20	+38½	+5½	40°		24.8.88	8.16	-140	+3	74°	+2½
25.7	8.20	+38	+2½	40°		25.8.88	9.55	+79½	+5½	74°	+5
26.7	8.20	+40½	+½	35°		26.8.	8.18	+86	+6½	74°	+7
27.7	8.20	+41½	+1½	35°		27.8.					
28.7	9.40	+43	+1	35°		28.8	8.20				
29.7	10.00	+44½	+2	38°							
30.7	8.20	+46	+1½	100°							
1.3.7	8.25	+57	+11	100°							
2.1.8	8.20	+60	+3	80°							
2.8	8.20	+71½	+11½	100°							
3.8	8.15	+80	+8½	80°							

1.5.
1.0
1.0
1.0
1.5
1.5
3.5
2.5
2.75

Watch no 2. Pallmark # 56 608 $22.50.

Date	Time	Error by Clock	Rate	Temp	Bat.	Calc. Error 24 hrs	Date	Time	Error	Rate	Temp	Bat.	Calc. Error 24 hrs
28.6.	13.25	+34½					3.8.88	8.15	-202	-8	80°	D.U	
29.6	8.40	+28	-7	66°	D.U.	-8¾	4.8.88	8.15	-210	-5	80°		
30.6	8.40	+21	-7	66°	D.U.		5.8.88	8.30	-215	-5	80°	D.U	-4¾
1.7	10.00	+12½	-8½	69	"	-8	6.8.88	8.15	-219	-4	80°		
2.7	11.00	+4½	-8¼	69		-8	7.8.88	8.25	-224½	-7½	80°	D.U.	
3.7	8.20	± 2	-6½	70		-7	8.8.88	8.20	-235	-8¾	78°	D.D.	
4.7	8.30	-7½	-5½	74			9.8.88	8.15	-243½	-7½	78°	D.D.	
5.7	8.40	-11½	-4	76	D.U		10.8.88	8.15	-252	-8½	78°	D.U.	
6.7	8.25	-19	-7½	78	D.U		11.8.88	8.10	-265	-13	76°	D.U.	
7.7	8.30	-24	-5	78	D.D								
8.7	9.50	-32½	-8½	95	D.U.	-7¾	12.8.88	10.00	-275	-10	80°	D.U	-9¾
9.7	8.15	-44½	-11¾	100	D.U.	-12½	13.8.88	8.15	-284	-9	78°	D.U	-9¾
10.7	9.8	-56	-12	108	D.D.	-11½	14.8.88	8.20	-292	-8	80°	D.U	
11.7	8.50	-65	-9¾	74	D.U		15.8.88	8.20	-302¾	-10¼	80°		
12.7	8.25	-68	-1¾	69	D.U		16.8.88	8.20	-314	-11¼	80°		
13.7	8.05	-67¾	+¼	69	D.U		17.8.88	8.25	-322	-11	82°		
14.7	8.15	-69	-1¼	69	D.D		18.8.88	8.35	-332¾	-10¾			-6.88¾
15.7	10.00	-82	-13	100	D.U.	-12	19.8.88	8.20	-344½	-12	80°		-11¾
16.7	8.20	-94	-12	100		-13	19.8	10.20	-357	-12½	80°		
17.7	8.20	-103	-9	100			20.8	8.20	-366	-9	82°		
18.7	8.15	-114½	-11½	100			21.8	12.05	-368¾	-2¾			-18.88
19.7	8.10	-125¾	-11¼	100				8.20	-375	-6¼	80°		-7½
20.7	8.20	-138¾	-13	110				19.25	-386	-7	78°		
21.7	8.25	-144¾	8	78	D.U		22.8	18.35	-386½	¼	78°		
22.7	10.05	-153¾	-7	78		-8¾	23.8	5.20	-390	-7½	78°		-8¾
23.7	8.25	-160	-6½	76°			24.8	10.15	-399	-9	76°		
24.7	8.20	-159¾	+¾	35°	D.U			10.45	-400	-2½			-8.5
25.7	8.20	-158	+1¾	35°	D.U		25.8	8.16	-401½	-1½	74°	D.U.	-16½
26.7	8.20	-157	-1	35°	D.U		26.8	19.00	-403½	-16½	74°		-16½
27.7	8.20	-161	-2	35°			27.8	8.20	-405	-1½	74°		-20
28.7	8.20	-161	0	35°									
29.7	10.00	-162	-1	35°									
30.7	8.20	-164	-2	35°									
31.7	8.25	-177	-13	100°									
1.8	8.20	-180½	-3½	40°									
2.8	8.20	-193	-12½	100°									

Watch No 3 Paillard Non Mag. 6 ⌀ 350.438 $ 7.50 (12)

Date	Hour	Error by Clock	Rate	Temp F	Cond	Rate for 24 hrs
28.6	13.25	+77	-8	66°	D.U.	-3½
29.6	8.40	+74				
30.6	8.40	+69	-5	66°	"	
1.7	10.00	+53	-16	69°	"	-15½
2.7	11.00	+38	-15	69°	"	-14½
3.7	8.20	+23	-15	70°	"	-16½
4.7	8.30	+9	-14	74°	"	
5.7	8.40	-26	-35	76°	D.U.	
6.7	8.25	-42½	-16½	76°	D.U.	
7.7	8.30	-57½	-15	76°	D.D.	
8.7	9.50	-91	-33½	95°	D.U.	-34½
9.7	8.15	-98½	-2½	100°	D.U.	
10.7	9.45	-105½	-7	108°	D.D.	-95½
11.7	8.50	-116	-18½	74°	D.U.	
12.7	8.25	-110½	+4½	89°	D.U.	
13.7	8.05	-98½	+21	89°	D.U.	
14.7	8.15	-76	+22½	89°	D.U.	
15.7	10.00	-113½	-37½	100°	D.U.	-35½
16.7	8.20	-167	-53½	100°	"	-57½
17.7	8.20	-202	-35	100°	"	
18.7	8.15	-238½	-36½	100°	"	
19.7	8.10	-280½	-41½	100°	"	
20.7	8.20	-334	-53½	100°	"	
21.7	8.25	-362½	-3½	79°	D.U.	
22.7	10.05	-368½	-6	78°	"	-5½
23.7	8.25	-353½	+7½	78°	"	-7½
24.7	8.20	-328½	+27	85°	D.U.	
25.7	8.20	-301	+26½	88°	D.U.	
26.7	8.20	-290½	+13½	85°	"	
27.7	8.20	-279	+16½	85°	"	
28.7	8.40	-250	+29	85°	"	
29.7	10.00	-227½	+22½	85°	"	-21½
30.7	8.20	-196½	+32½	85°	"	-19½
☾ 31.7	8.25	-214	-17½	100°	"	
☾ 1.8	8.20	-187½	+26½	100°	"	
☾ 2.8	8.20	-158	+29½	100°	"	

Date	Hour	Error	Rate	Temp F	Cond	Rate for 24 hrs
3.8	8.15	-150	+8	80°	D.U.	
4.8	8.15	-98	+52	80°	"	
5.8	9.30	-87	+11	80°	D.U.	+10½
6.8	8.15	-53	+34½	80°	"	
7.8	8.25	-19	+34	80°	D.U.	+33½
8.8	8.20	-27	-8	76°	D.D.	
9.8	8.15	-31½	-4½	78°	D.D.	
10.8	8.15	+02	+33½	78°	D.D.	
11.8	8.10	-61½	-63½	76°	D.U.	
12.8	10.00	-31	+30½	80°	D.U.	+28
13.8	8.15	+34	+65	78°	D.U.	+70
14.8	8.20	+82	+48	80°	D.U.	
15.8	8.20	+120	+38	80°	"	
16.8	8.20	+162	+42	80°	"	
17.8	8.25	+197½	+35½	82°	"	
	9.35	+193½	-4		"	
18.8	8.20	-163	+26½	84°	"	+21½
19.8	10.20	-136	+27	84°	"	+26
20.8	10.20	-116½	+19½	82°	"	
	12.05	-483	-366		"	
21.8	8.20	-466	+17	80°	"	+20½
22.8	8.25	-425	+41	78°	"	
	11.35	-448	-23	78°	"	
23.8	8.20	-439½	+8½	78°	"	+9½
	10.15	-371	+68½	76°	"	+63½
24.8	10.45	-423	-52½		"	
25.8	8.15	-367	+56	76°	D.U.	+63
26.8	10.00	-352	+15	76°	"	+14½
27.8	8.20	-293	+61	76°	"	+49

Watch No 14 Waltham 3,457,605 $21.00

(13)

Date	Time	Error Stop Watch	Rate	Temp	Cond	Rate for 24 hrs.
28.6	13.25	-19	stopped	66°	D.U.	—
29.6	8.40	+24½	stopped	66°	"	—
30.6	8.40	+9	stopped	69°	"	—
Feb. 1.7	10.00	-51	stopped	69°	"	—
2.7	11.00	-17½	+33½	69°	"	+32
3.7	8.20	+9½	+27½	70°	"	+30½
4.7	8.30	+42	+32½	72°	"	+32½
5.7	8.40	+49½	+7½	76°	P.U.	+7½
Mar. 6.7	8.25	+85	+35½	78°	D.U.	+35½
7.7	8.30	+121½	+36½	78°	D.U.	+36½
8.7	9.50	+170½	+49½	95°	P.U.	+49½
9.7	8.15	+219½	+49½	100°	D.U.	+49½
10.7	9.08	+266½	+46½	102°	D.U.	+46½
11.7	8.50	+263	+16	72°	P.U.	+16
12.7	8.25	+309½	+46½	49°	P.U.	+46½
Apr. 13.7	8.05	+347½	+38	49°	D.U.	+38
14.7	8.15	+392½	+45½	49°	D.U.	+45½
15.7	10.00	+553½	+33½	100°	D.U.	+33½
16.7	8.20	+582	+28½	100°	"	+28½
17.7	8.20	+619½	+37½	100°	"	+37½
May 18.7	8.15	+638	+18½	100°	"	+18½
19.7	8.10	+693½	+55½	110°	"	+55½
20.7	8.20	+678	+20½	110°	"	+20½
21.7	8.25	-224	stopped	78°	D.U.	—
22.7	10.05	+165	stopped	78°	D.U.	—
23.7	8.25	+125½	+26½	78°	"	+26½
24.7	8.20	+55	+12½	125°	D.U.	+12½
25.7	8.25	+01	stopped	38°	D.U.	—
26.7	8.20	+21	+20	45°	"	+20
27.7	8.20	+37½	+16½	35°	"	+16½
June 28.7	8.40	+53½	+15½	35°	"	+15½
29.7	10.00	+69	+15½	35°	"	+15½
30.7	8.20	+85½	+15½	35°	"	+15½
H 31.7	8.25	+110	+23½	100°	"	+24½
G. 1.8	8.20	+119	+9	110°	"	+9
H 2.8	8.20	+115	stopped	100°	"	—

Date	Hour	Error	Rate	Temp	Cond	Rate for 24 hrs.
3.8	8.15	+235½	stopped	80°	D.U.	—
4.8	8.15	-23	stopped	80°	"	—
5.8	9.30	+195½	+219	80°	P.U.	+207½
6.8	8.15	+240½	+45	80°	"	+47½
7.8	8.25	+261½	+21½	80°	D.U.	+21½
8.8	8.20	+291	+29½	76°	D.U.	+29½
9.8	8.15	+320½	+29½	78°	D.U.	+29½
10.8	8.15	+500	+178½	78°	P.U.	+178½
11.8	8.10	+382	-118	76°	P.U.	-118
12.8	10.00	+406	+24	80°	D.U.	+22½
13.8	8.15	+431	+25	78°	D.U.	+27
14.8	8.20	+453½	+22½	80°	D.U.	+21½
15.8	8.20	+477½	+25	80°	"	+25
16.8	8.20	+498½	+20½	80°	"	+20½
17.8	8.25	+521	+22½	82°	"	+22½
	9.35	+550	+29	"	"	+29
18.8	8.20	+571½	+21½	82°	"	+46½
19.8	10.20	+593½	stopped	82°	"	—
20.8	8.20	+614	+37½	82°	"	+41
	12.05	-277½	-391½	"	"	—
21.8	8.20	-311	-34½	80°	"	-48
22.8	8.25	-360	-46	78°	"	-46
	11.35	-423	-63	78°	"	—
23.8	8.20	-442½	-25½	76°	"	-29
	10.15	-462	-16	76°	"	-14½
24.8	10.45	-522	-58	"	"	—
25.8	8.15	-548	-26	76°	D.U.	-29
26.8	10.00	-570½	-22½	76°	"	-39½
27.8	8.20	-617	-46½	76°	"	-27½
28.8	8.20	-641	-24	76°	"	

Watch No. 5. Waltham 3,5314,801L $18.00 (112)

Date	Time	Comp. 24 Clock	Rate	Temp	Beat	Date	Hour	Comp.	Rate	Temp	Beat	Comp. 24 Clock
28.6	13.25	-12.5	stopped	66°	D.U.	3.8	9.15	-12.62	-39½	80°	D.U.	-39½
29.6	8.40	+12½				4.8	9.15	-13.02	-40	80°	..	-40½
30.6	8.40	-22½	-39½	66°	- 39	5.8	9.20	-13.28	-26	80°	P.U.	-24½
1.7	10.00	-65½	-44	69°	- 39	6.8	8.15	-13.55	-30	80°	..	-31¼
2.7	11.00	-99	-33½	69°	- 33	7.8	8.25	-13.92	-37	80°	D.U.	-37
3.7	8.20	-131	-32	70°	- 32	8.8	8.20	-14.35	-42	76°	D.U.	-40
4.7	8.30	-171½	-40½	74°	- 40	9.8	8.15	-14.79½	-44½	78°	D.U.	-40½
5.7	8.40	-203½	-32	75°	P.U. 32	10.8	8.15	-14.91½	-12½	78°	P.U.	-42½
6.7	8.25	-238½	-35½	78°	D.U. 35	11.8	8.10	-15.33½	-41½	75°	P.U.	-42½
7.7	8.30	-276	-37½	78°	D.U. 37	12.8	10.00	-15.71	-42½	80°	D.U.	-39½
8.7	9.50	-305	-29	95°	P.U. 29	13.8	8.15	-15.86½	-36½	78°	D.U.	-38
9.7	8.15	-340	-35	100°	D.U. 35	14.8	8.20	-16.05½	-42½	80°	D.U.	-42½
10.7	9.05	-381	-41	108°	D.U. 39	15.8	8.20	-16.51	-42½	80°	..	-42½
11.7	8.50	-407½	-26½	74°	D.U. 27	16.8	8.20	-17.05	-54	80°	..	-57
12.7	8.25	-427½	-20	69°	P.U. 20	17.8	8.25	-17.72	-67	82°	..	-64
13.7	8.05	-459	-31½	69°	D.U. 32		9.35	-20.22	stopped			
14.7	8.15	-500½	-41½	69°	D.U. 39	18.8	8.20	-20.58	-36½	84°	..	-54½
15.7	10.00	-524	-40½	100°	D.U. 37	19.8	10.20	-20.87	-57½	84°	..	-55¼
16.7	8.20	-577	-36	100°	- 36	20.8	8.20	-21.41	-54	82°	..	-57½
17.7	8.20	-602½	-32½	100°	- 32		12.05	-28.82	-31½		..	
18.7	8.15	-650½	-41½	100°	- 41	21.8	8.20	-30.11	-129	80°	..	-153
19.7	8.10	-689	-38½	100°	- 38	22.8	8.25	-32.25	-115½	78°	..	-115½
20.7	8.20	-727½	-38½	110°	- 38		11.35	-33.93	-62½	78°	..	
21.7	8.25	-765½	-39½	78°	D.U. 39	23.8	8.20	-35.30	-93½	78°	..	-105
22.7	10.05	-804½	-35	78°	- 38	24.8	10.15	-36.02	-124	76°	..	-114¼
23.7	8.25	-836	-32½	78°	- 37		10.45	-36.67	-63	76°	..	
24.7	8.20	-872½	-38½	85°	D.U. 37	25.8	9.15	-36.91½	-152½	74°	D.U.	-102½
25.7	8.20	-913	-38½	85°	D.U. 38	26.8	10.00	-37.78½	-153½	74°	..	-143½
26.7	8.20	-949½	-36½	85°	- 36	27.8	8.20	-39.03	-126½	74°	..	-137½
27.7	8.20	-987	-37½	85°	- 37	28.8	8.20	-40.53	-151	74°	..	
28.7	6.40	-1020½	-41½	85°	- 41							
29.7	10.00	-1069	-39½	85°	- 39							
30.7	8.20	-1105½	-38½	85°	- 38							
N. 31.7	8.25	-1142	-34	100°	- 34							
N. 1.8	9.20	-1176	-34½	80°	- 34							
N. 2.8	8.20	-1222½	-43½	100°	- 43							

Watch No. 6. Waltham # 3,511,918 $. 5.00

Date	Time	Error Watch	Rate	Temp	Lie	Rate for 24 hrs
28.6	13.25	-44½	stopped	66°	D.U.	—
29.6	8.40	+46	stopped	66°	"	—
30.6	8.40	+13½	+23	69°	-	+16¾
1.7	10.00	+5½	stopped	69°	-	—
2.7	11.00	-22	stopped	70°	-	—
3.7	8.20	[illegible]	+10½	74°	-	+18½
4.7	8.30	+38½	-18¾	76°	P.U.	-18¾
5.7	8.40	-71½	-9½	76°	D.U.	-9½
6.7	8.25	-80½	-2½	76°	D.U.	-2½
7.7	8.30	-101	-23¾	90°	P.U.	-33¾
8.7	9.50	-144¾	-27½	100°	D.U.	-27½
9.7	8.15	-172	-34	100°	D.U.	-34
10.7	9.05	-206	-32¾	74°	P.U.	-33¾
11.7	8.50	-238¾	-25¾	74°	P.U.	-25¾
12.7	8.25	-264	-15¾	74°	P.U.	-15¾
13.7	8.05	-279¾	-14¾	74°	D.U.	-19¾
14.7	8.15	-294½	-32½	100°	D.U.	-30¾
15.7	10.00	-327	-24	100°	-	-24¾
16.7	8.20	-351	-17	100°	-	-17
17.7	8.20	-368	-19½	100°	-	-19½
18.7	8.15	-387½	-19½	100°	-	-19½
19.7	8.10	-407	-21½	100°	-	-21½
20.7	8.20	-428½	-17½	78°	D.U.	-17½
21.7	8.25	-449	-13¾	78°	-	-13¾
22.7	10.05	-462¾	-12¾	75°	-	-13¾
23.7	8.25	-475	-12	45°	D.U.	-12
24.7	8.20	-487	-10½	57°	-	-10½
25.7	8.20	-497½	-12½	45°	-	-12½
26.7	8.20	-510	-16	35°	-	-16
27.7	8.20	-526	-12	35°	-	-12
28.7	8.40	-538	-22	35°	-	-20¾
29.7	10.00	-560	-21	38°	-	-22½
30.7	8.20	-581	-39	100°	-	-39
H 31.7	8.25	-620	-23¾	40°	-	-23¾
G. 1.8	8.22	-643¾	stopped	100°	-	—
H. 2.8	8.20	-[illegible]				

Date	Time	Error	Rate	Temp	Lie	Rate for 24 hrs
# 3.8	8.25	-21½	-20½	80°	D.U.	-21½
4.8	8.15	-47	-25½	80°	"	-25½
5.8	9.30	-85½	-38½	80°	P.U.	-36½
6.8	8.15	-123½	-37	80°	-	-37
7.8	8.25	-163	-26½	80°	D.U.	-26½
8.8	8.20	-165	-22	76°	D.U.	-22
9.8	8.15	-185	-20	77°	D.U.	-20
10.8	8.15	-224	-39	70°	P.U.	-39
11.8	8.10	-259	-35	76°	P.U.	-35
12.8	10.00	-294½	-37½	80°	D.U.	-35
13.8	8.15	-327	-32½	78°	P.U.	-33
14.8	8.20	-359½	-17½	80°	D.U.	-17½
15.8	8.20	-379½	-35½	80°	-	-35½
16.8	8.20	-402½	stopped	80°	-	—
17.8	8.25	+17.33¾	+18½	82°	-	+18½
	9.35	+155½	stopped			
18.8	8.20	+324½	-911	82°	-	-85¾
19.8	10.20	-581	-92½	82°	-	-84½
20.8	8.20	-1314	-733	82°	-	-82¾
	12.05	-1682½	-368½			
21.8	8.20	+920	+2602¾	80°	-	+2080¾
22.8	8.25	+2086½	-511½	78°	-	-511½
	11.35	stopped				

Watch No 7 Elgin #3,013,718 sent to N.Y. 2.7.88 + exchanged for #3,013,719 8.8.50. (16)

	Date	Time	Error Corr. Corr.	Rate	Temp	Bed	Rate for 24 hrs		Date	Time	Error	Rate	Temp	C	Rate for 24 hrs
February	28.6.	13.25	+94	stopped	66°	D.U.	—		3.8	8.15	+99½	+36½	80°	D.U.	+363½
	29.6.	8.40	−39½						4.8	8.15	+113¾	+37½	80°		+337½
	30.6.	8.40	—	stopped	66°	-	—		5.8	9.20	−08	stopped	80°		—
	1.7	10.00	—	stopped	69°	-	—		6.8	8.15	+94	+102	80°		+107½
	2.7	18.10	+17	+17	70°	-	+17		7.8	8.25	+93½	+1½	80°	D.U.	+1½
	3.7	8.20	+34						8.8	8.20	+132	+36½	76°	D.U.	+36½
	4.7	8.30	+65½	+31½	74°	-	+31½		9.8	8.15	−035	stopped	76°	D.U.	—
March	5.7	8.40	+124½	+58½	76°	D.U.	+58½		10.8	8.15	+25½	+39½	76°	D.U.	+29½
	6.7	8.25	+156	+31½	78°	D.U.	+31½		11.8	8.10	+67½	+41½	76°	D.U.	+91½
	7.7	8.30	+208	+52	78°	D.U.	+52								
Hot	8.7	9.50	+246	+38	95°	D.U.	+36		12.8	10.00	+128	stopped	80°	D.U.	—
	9.7	8.15	+267	+21	100°	D.U.	+23½		13.8	8.15	−02½	+37½	78°	D.U.	+29½
	10.7	9.08	+310	+43	105°	D.U.	+47½		14.8	8.20	+33	+33½	80°	D.U.	+33½
	11.7	8.50	+346	+36	76°	D.U.	+39½		15.8	8.20	+67½	+34½	80°		+37½
Cold	12.7	8.25	+385½	+40½	40°	D.U.	+41½		16.8	8.20	+108	+38½	80°		+38½
	13.7	8.05	+411½	+26	40°	D.U.	+26		17.8	8.25	+146	+40	83°		+240
	14.7	8.15	+432½	+22½	40°	D.U.	+23½			9.35	+452½	stopped			
Hot	15.7	10.00	+466½	+30½	100°	D.U.	+28½		18.8	8.20	−168	+284½	82°		+302½
	16.7	8.20	+488½	+23½	100°	-	+29½		19.8	10.20	+102	+270	82°		+249½
	17.7	8.20	+515½	+27½	100°	-	+27½		20.8	8.20	+233½	+133½	83°		+145½
	18.7	8.15	+540	+24½	100°	-	+24½			12.05	−62½	−300			
	19.7	8.10	+573½	+33½	100°	-	+33½		21.8	8.20	−507	−442½	80°		−511½
	20.7	8.20	+595	+21½	110°	-	+21½		22.8	8.25	−924½	−441½	78°		−444½
Mean	21.7	8.25	+619½	+24½	78°	D.U.	+24½			11.35	−1017	−90½	78°		
	22.7	10.05	+646	+26½	78°	-	+24½		23.8	8.20	−1256½	−239½	78°		−237½
	23.7	8.25	+674½	+28½	78°	-	+30½			10.15	−1811½	−253	76°		−234½
	24.7	8.20	+708½	+32	40°	D.U.	+33		24.8	10.45	−1971	−59½	76°		
	25.7	8.20	+738½	+30	38°	-	+30		25.8	8.15	−1688½	−39½		D.U.	−42
	26.7	8.20	+768½	+31½	40°	-	+31½		26.8	10.00	−1671	−62½	76°		−58½
Cold	27.7	8.20	+797½	+29½	38°	-	+29½		27.8	8.20	−1708	−32½	76°		−34½
	28.7	8.40	+817	+29½	38°	-	+28½		28.8	8.20	−1763	−62½	76°		
	29.7	10.00	+846½	+28½	38°	-	+28½								
	30.7	8.20	+873	+28½	100°	-	+38½								
N.	31.7	8.20	+862½	+17½	40°	-	+17½								
E.	1.8	8.20	+924	+36½	100°	-	+36½								
H.	2.8	8.20	+960												

Watch No 8 Elgin # 3,0140 188 B. 6.25. (17.

Hand polished 28,1911 2 mins.

Date	Time	Error off Clock	Rate	Temp	Beat	Rate for 24 hrs
28.6	13.25	+139	stopped	66°	D.U.	—
29.6	8.40	−302½				
30.6	8.40	−32	± 1⅞	66°	..	−1⅞
1.7	10.00	+47	stopped	69°	..	—
2.7	11.00	−12	stopped	69°	..	—
3.7	8.20	−8	+4	70°	..	+4⅛
4.7	8.30	−4½	+3½	70°	..	+3½
5.7	8.40	+107	−8½	75°	D.U.	−8½
6.7	8.25	+109	+2	78°	D.U.	+2
7.7	8.30	+100	−9	78°	D.U.	−9
8.7	9.50	+82⅞	−17½	95°	D.U.	−16⅞
9.7	8.15	+84½	+1½	100°	D.U.	−1½
10.7	9.08	+80	−4½	108°	D.U.	−4½
11.7	8.50	+74	−6	116°	D.U.	−6
12.7	8.25	+66⅞	−7½	109°	D.U.	−7½
13.7	8.05	+55½	−11½	109°	D.U.	−11½
14.7	8.15	+39⅞	−15⅞	109°	D.U.	−15⅞
15.7	10.00	+44½	+4⅞	100°	D.U.	+4⅞
16.7	8.20	+46½	+1⅞	100°	.	+1⅞
17.7	8.20	+50½	+4	100°	.	+4
18.7	8.15	+47	−3½	100°	.	−3½
19.7	8.10	+45	−2	100°	.	−2
20.7	8.20	+49	+4	110°	.	+4
21.7	8.25	+49	0	78°	.	0
22.7	10.05	+50⅞	+1⅞	78°	.	+1⅞
23.7	8.25	+46⅞	−4	78°	.	−4⅛
24.7	8.20	+40½	−6½	105°	D.U.	−6½
25.7	8.20	+34	−6½	38°	.	−6½
26.7	8.20	+29	−5	60°	.	−5
27.7	8.20	+17⅞	−11⅛	35°	.	−11⅛
28.7	8.40	+05½	−12½	35°	.	−12½
29.7	10.00	+22	−7½	35°	.	−7
30.7	8.20	−10⅞	−8⅞	38°	.	−8⅞
H. 31.7	8.25	−10	+⅞	100°	.	+⅞
B. 1.8	8.20	−21	−11	100°	.	−11
H. 2.8	8.20	−29	−8	100°	.	−8

Date	Time	Error	Rate	Temp	Beat	Rate for 24 hrs
	°					
3.8	8.15	−25	+4	90°	D.U.	+4
4.8	8.15	−27	−2	90°	..	−2
5.8	9.30	−45½	−18½	80°	D.U.	−17½
6.8	8.15	−57	−12	80°	..	−14½
7.8	8.25	−66	−7	80°	D.U.	−7
8.8	8.20	−79½	−13½	76°	D.U.	−13½
9.8	8.15	−90½	−11	75°	D.U.	−11
10.8	8.15	−112	−21½	75°	D.U.	−21½
11.8	8.10	−125	−13	76°	D.U.	−13
12.8	10.00	−125½	+3½	80°	D.U.	+3½
13.8	8.15	−122	−½	78°	D.U.	−½
14.8	8.20	−133½	−11½	80°	D.U.	−11½
15.8	8.20	−133½	0	80°	..	0
16.8	8.20	−139	−5½	80°	..	−5½
17.8	8.25	−150	−11	82°	..	−11
	9.35	−709½	stopped			—
18.8	8.20	−1097½	−388½	80°	..	−388½
19.8	10.20	−1462½	−364½	86°	..	−357½
20.8	8.20	−1700½	−237½	82°	..	−232
	12.05	−2039½	−339			
21.8	8.20	−1967	+72½	80°	..	+67½
22.8	8.25	−1522½	+446½	78°	..	+436½
	11.35	−1122½	−402	78°	..	
23.8	5.20	−2017½	−899½	78°	..	−1040½
24.8	10.15	−3118½	−1101½	76°	..	−977½
	10.45	−3105	+13½		..	
25.8	8.15	−3663	−558		..	−623
26.8	10.00	−4283	−620	74°	..	−578
27.8	8.20	−4777½	−494½	..	..	
28.8	8.20	−5367	−590	..	..	−550½

Watch No 9. Hampden # 373,661 $2.50.

(18)

Date	Time	Error Stand	Rate	Temp	B	Rate for 24 hrs
28.6	13.25	+27	+19	66°	D.U	+23¾
29.6	8.40	+46	+46	66°	..	+20½
30.6	8.40	+69½	+69½			
1.7	10.00	+92	+22½	69°	..	+21½
2.7	11.00	+116	+24	69°	..	+23
3.7	8.20	+138½	+22½	70°	..	+23¾
4.7	8.30	+161	+23½	71°	..	+23¾
5.7	8.40	+186	+5	76°	D.U	+5
6.7	8.25	+191½	+23½	78°	D.U	+23½
7.7	8.30	+217	+23½	78°	D.U	+23½
8.7	9.50	+219	+2	95°	D.U	+2
9.7	8.15	+237	+18	100°	D.U	+19¼
10.7	9.08	+252	+15	105°	D.U	+14½
11.7	8.50	+253	+1	74°	D.U	+1
12.7	8.25	-24½	stopped	49°	D.U	—
13.7	8.05	-4½	+20	49°	D.U	+20
14.7	8.15	+21½	+25½	49°	D.U	+25½
15.7	10.00	+39½	+18	100°	D.U	+16¾
16.7	8.20	+46½	+7	100°	D.U	+7½
17.7	8.20	+60	+13½	100°	D.U	+13½
18.7	8.15	+76	+16	100°	-	+16
19.7	8.10	+82½	+6½	100°	-	+6½
20.7	8.20	+90½	+8	100°	-	+8
21.7	8.25	-27	stopped	78°	D.U	—
22.7	10.05	-16	stopped	78°	-	—
23.7	8.25	+2	+18	78°	-	+19¼
24.7	8.20	+26½	24½	65°	D.U	—
25.7	8.25	-15	stopped	38°	..	—
26.7	8.20	+09	stopped	65°	..	—
27.7	8.20		stopped	35°	..	—
28.7	8.40		stopped	35°	..	—
29.7	10.00		stopped	35°	..	—
30.7	8.20	+10½	stopped	35°	..	—
# 31.7	8.25	+24	+15½	100°	-	+13½
C 1.8	8.30	+10	stopped	60°	-	—
N 2.8	8.20	+26½	-9½	100°	-	-9¼

Date	Time	Error	Rate	Temp	B	Rate for 24 hrs
3.8	8.15	+46	+17¾	80°	D.U	+17¾
4.8	8.15	+60	+14	80°	..	+14
5.8	9.30	-31	stopped	80°	D.U	—
6.8	8.15	-35½	-4½	80°	..	-4¾
7.8	8.25	-23	+12½	80°	D.U	+12½
8.8	8.20	-07	+16	76°	32	+16
9.8	8.15	+13	+20	78°	D.U	+20
10.8	8.15	+07	-06	78°	D.U	-06
11.8	8.10	+12½	+5½	76°	D.U	+5½
12.8	10.00	+26	+13½	80°	30	+12½
13.8	8.15	+37	+11	78°	D.U	+11¾
14.8	8.20	+53	+16	80°	D.U	+16
15.8	8.20	+66½	+12½	76°	..	+12½
16.8	8.20	-459½	-16½	80°	..	-164½
17.8	8.25	-475½	-16½	83°	..	-16½
18.8	9.35	-2559	stopped			
	Tomb L	Arrive	2544	80°	-	
19.8						

Watch No. 10 Patek, Philippe & Co. 76,772 (19)

Date	Time	Error of Clock	Rate	Temp.	Pos.	Rate for 24 hours	Date	Time	Error	Rate	Temp.	Pos.	Rate for 24 hours
28.6	13.25	-65					3.8	8.15	-6369	-166	80°	DU	-166
29.6	8.40	+861	+181?	66°	DU	[illegible]	4.8	8.15	-6522	-173	80°	--	-173
30.6	8.40	-600	-1461	66°	DU	[illegible]	5.8	9.30	-6723	-181	80°	DU	-172
Parliament 1.7	10.00	-5941	-192½	69°	DU	-169½	6.8	8.15	-6895	-1621	80°	--	-173½
2.7	11.00	-7061	-192½	69°	-	-169½	7.8	8.25	-7063	-173½	80°	DU	-173½
3.7	8.20	-949	-162½	70°	-	-178½	8.8	8.20	-7234	-170½	76°	DU	-170½
4.7	8.30	-1131	-182	70°	-	-182	9.8	8.15	-7404½	-170½	78°	DU	-170½
5.7	8.40	-1318	-187	76°	DU	-187	10.8	8.15	-7581	-177	78°	DU	-177
6.7	8.25	-1499½	-182½	78°	DU	-181½	11.8	8.10	-7741	-159½	76°	DU	-159½
7.7	8.30	-1679½	-180½	78°	DU	-180½	12.8	10.00	-7925	-184½	80°	DU	-171½
Hot 8.7	9.50	-1862½	-183	95°	DU	-175½	13.8	8.15	-8082½	-157½	78°	DU	-168½
9.7	8.15	-2025	-162½	100°	DU	-169½	14.8	8.20	-8253	-169½	80°	DU	-169½
10.7	9.08	-2205	-180	105°	DU	-175½	15.8	8.20	-8423	-171	80°	--	-171
11.7	8.50	-2371½	-170½	76°	DU	-176	16.8	8.20	-8588½	-165½	80°	--	-165½
Cold 12.7	8.25	-2549	-177½	49°	DU	-177½	17.8	8.25	-8761	-173½	80°	--	-172½
13.7	8.05	-2728	-179	49°	DU	-179		19.35	-9392½	Stopped		--	
14.7	8.15	-2920	-192½	49°	DU	-192½	18.8	8.20	-9558	-165½	80°	--	-172½
15.7	10.00	-3097½	-177½	100°	DU	-168½	19.8	10.00	-9737	-179	80°	--	-161½
Hot 16.7	8.20	-3253	-155½	100°	-	-167	20.8	8.20	-9893	-156	80°	--	-173¼
17.7	8.20	-3423	-170	100°	-	-170	21.8	12.05	-10193	-300½		--	
18.7	8.15	-3593½	-170½	100°	-	-170	22.8	8.20	-10325	-132	80°	--	-187
19.7	8.10	-3762½	-169	100°	-	-169	23.8	8.25	-10484	-159½	78°	--	-156½
20.7	8.20	-3932½	-167	100°	-	-167	24.8	11.35	-10679	-78	78°	--	-175½
21.7	8.25	-4102	-170	78°	DU	-170		8.20	-10911	-152	75°	--	
Cold 22.7	8.05	-4267½	-165½	78°	-	-173½		10.15	-10998	-87	76°	--	-173½
23.7	8.25	-4427	-160	78°	-	-172		10.45	-10959	+61	--	--	
24.7	8.20	-4594	-167	25°	DU	-167	25.8	8.25	-11110	-151½	76°	--	-156½
25.7	8.25	-4762	-168	25°	-	-168	26.8	10.00	-11283	-163	76°	--	-152½
26.7	8.20	-4929	-167	25°	-	-167	27.8	8.20	-11439½	-156½	76°	--	-166½
27.7	8.20	-5096	-167	25°	-	-167	28.8	8.20	-11603	-163½	76°	--	
28.7	8.20	-5263	-167	25°	-	-167							
29.7	10.00	-5431½	-168½	25°	-	-168½							
30.7	6.20	-5599	-167½	25°	-	-177½							
N. 31.7	8.25	-5765	-176	100°	-	-176							
8.1.8	8.20	-6024	-179½	100°	-	-179½							
9.2.8	8.20	-6203	-179	100°	-	-179							

Watch No. 11 – My own golden one.

	Date	Time	Error @ Beh.	Rate	Temp.	Ex.	Sec.	
Rehearsing	28.6	13.25	+56½	-4¾	66°	D.U.	-4	
	29.6	8.40	+51¾	-7½	66°	-		
	30.6	8.40	+44¼	-6	69°	-	-5½	
	1.7	10.00	+38½	-5¾	69°	-	-4½	
	2.7	11.00	+33¾	-4¾	70°	-	-4	
	3.7	8.20	+29	-2	70°			
	4.7	8.30	+27	-13	76°	P.U.		
Mum	5.7	8.40	+14	-1¾	76°	D.U.		
	6.7	8.25	+12¼	-2¼	76°	D.U.		
	7.7	8.30	+11½	-11	95°	P.U.	-1½	
Hot	8.7	9.50	-22½	-3½	100°	D.U.	-3½	
	9.7	8.15	-26	-20	108°	D.U.	-10	
	10.7	9.08	-52	-13	110°	P.U.		
M.	11.7	8.50	-65	+3	49°	P.U.		
Cold	12.7	8.25	-62	-10	49°	D.U.		
	13.7	8.05	-72	-32½	49°	D.U.		
	14.7	8.15	-104½	-4¾	100°	D.U.		
Hot	15.7	10.00	-109¼	-6¾	100°	-		
	16.7	8.20	-116	-5	100°	-		
	17.7	8.20	-121	-4½	100°	-		
	18.7	8.15	-125½	-8½	100°	-		
	19.7	8.10	-134	+10	110°	-		
	20.7	8.20	-124	-18	78°	D.U.		
Mum	21.7	8.25	-142	-6½	78°	-		
	22.7	18.05	-148½	Remarks				
	23.7	8.25	-	-				
	2							

Watch No 12 Pallard. # 55821 Property of Mr Starr. (21)

Date	Time	Error Clock	Rate	Temp	Dial	Rate for 24 hrs
18.7	11.23	+4½	-17½	100°	D.U.	-15½
19.7	8.10	-8	-22	110°	D.U.	
20.7	8.20	-30	-25½	78°	D.U.	
21.7	8.25	-55½	-25	78°	D.U.	-24½
22.7	10.05	-80½	-20½	78°	D.U.	-22
23.7	8.25	-101	-23	45°	D.U.	
24.7	8.20	-124	-24½	38°	-	
25.7	8.20	-148½	-24½	45°	-	
26.7	8.20	-173	-25½	35°	-	
27.7	8.20	-198½	-25½	35°	-	
28.7	8.40	-224	-27	35°	-	-25½
29.7	10.00	-251	-24½	38°	-	-26
30.7	8.20	-275½	-26½	100°	-	
H 31.7	8.25	-302	-25	40°	-	
B. 1.8	8.20	-327	-27	100°	-	
H. 2.8	8.20	-354	-26½	80°	-	
3.8	8.15	-380½	-37½	80°	-	
4.8	8.15	-405	-36	80°	D.U.	-34½
5.8	9.30	-441½	-28½	80°	-	
6.8	8.15	-475	-30	80°	D.U.	
7.8	8.25	-505	-32	76°	D.U.	
8.8	8.20	-537	-33	78°	D.U.	
9.8	8.15	-570	-31	78°	D.U.	
10.8	8.15	-601	-31½	76°	D.U.	
11.8	8.10	-6023	-33½	80°	D.U.	-31
12.8	10.00	-676	-39	76°	D.U.	-31½
13.8	8.15	-705	-32	80°	D.U.	
14.8	8.20	-737	-31	80°	-	
15.8	8.20	-768	-32½	80°	-	
16.8	8.20	-800½	-32½	80°	-	
17.8	8.25	-833	+10	8	-	
18.8	9.35	-823	-32	81°	-	-33½
19.8	8.20	-855	-36½	82°	-	-34½
19.8	10.20	-891	-32	82°	-	-35
20.8	8.20	-923	-26½		-	
	12.05	-1140	-25	80°	-	-33½
21.8	8.20	-1215				

Date	Time	Error Clock	Rate	Temp	Dial	Rate for 24 hrs
21.8	8.20	-1215	-34	76°	D.U.	
22.8	8.25	-1253	-40	76°	-	
	11.35	-1295				
23.8	8.20	-1297½	-31½	77°	-	-34
24.8	10.15	-1330½	-37½	76°	-	-35
	10.45	-1327	-42	76°	-	
25.8	8.15	-1359	-32	76°	D.U.	
26.8	10.00	-1397½	-38½	76°	-	-36
27.8	8.20	-1431	-33½	-	-	-35½
28.8	8.20	-1476	-45	-	-	

47) 10 4 13

1 1¾

Doubtful as hand had evidently engaged.

Watch No 13 Property of T. B. Starr. Maker T. B. Starr

Date	Time	Error by Clock	Rate	Temp	Pos	Rate for 24 hrs.
20.7	11.30	+20				
			+14s	78°	DU	+16½
21.7	8.15	+34				
			+29⅓	78°	DU	+27½
22.7	10.05	+63⅓				
			+10⅓	78°	DU	+11½
23.7	8.25	+74				
			−15	65°	DU	
24.7	8.20	+59				
			+33	38°	-	
25.7	8.20	+92				
			−08	25°	..	
26.7	8.20	+84				
			−20¾	35°	..	
27.7	8.20	+63¾				
			+3¾	25°	..	
28.7	8.40	+67				
			+10	25°	..	+5½
29.7	10.00	+77				
			−05	28°	..	−06
30.7	8.20	+72				
			−22	10°	..	
#31.7	8.25	+50				
			+ ½	60°	..	
E. 1.8	8.20	+19½				
			+3¾	10°	..	
H. 2.8	8.20	+23				
			+2½	90°	..	
3.8	8.15	+25½				
			0	80°	..	
4.8	8.15	+25½				
			stopped	80°	D.U	
5.8	9.30	−07				
			stopped	80°	..	
6.8	8.15	+01				
			stopped	80°	D.U	
7.8	8.25	+15				
			stopped	76°	D.U	
8.8	8.20	−21				
			+01	72°	D.U	
9.8	8.25	−20				
			stopped	72°	D.U	
10.8	8.15					
			stopped	76°	D.U	
11.8	8.10					
			stopped	80°		
12.8	10.00					

Watch No 16 Property of T. B. Starr Maker Elgin C. # 942,025

Date	Time	Error Stick	Rate	Temp	Bar	Rate by Mt.	Date	Time	Error Stick	Rate	Temp	Bar	
20.7	11.30	+9½	+41½	78°		[illegible]	25.8	8.15	+1760	+71	74°	20.	+ 6 6/4
21.7	8.25	+39¾	+30	78°		+49½	26.8	10.00	+1831	+59	74°		+ 6 3/2
22.7	10.25	+100¾	+45	78°		+48½	27.8	8.20	+1890	+51	74°		
23.7	8.25	+146¾	+40½	65°	20.		28.8	8.20	+1941				
24.7	8.20	+186½	+35½	85°									
25.7	8.20	+222	+38	85°									
26.7	8.20	+260	+34½	85°									
27.7	8.20	+294½	+37½	85°									
28.7	8.20	+332	+39	85°		-37							
29.7	10.00	+371	+26½	81°		+57							
30.7	8.20	+407½	+45½	100°									
H 31.7	8.25	+452½	+36½	100°									
C 1.8	8.20	+489	+42½	100°									
H. 2.8	8.20	+531½	+46	80°									
3.8	8.15	+577½	+44½	80°									
4.8	8.15	+622	+55½	80°	20.	+52½							
5.8	9.30	+677½	+47½	80°		+47½							
6.8	8.15	+725	+50½	80°	20.								
7.8	8.15	+775½	+45½	76°	20.								
8.8	8.20	+821	+46	76°	20.								
9.8	8.15	+873½	+52½	75°	20.								
10.8	8.15	+925	+47	75°	20.								
11.8	8.10	+972	+38½	80°	20.	+35½							
12.8	10.00	+1010½	+69½	75°	20.	+59½							
13.8	8.15	+1080	+[illegible]	80°	20.								
14.8	8.20	+1134½	+59	76°									
15.8	8.20	+1193	+65	79°									
16.8	8.20	+1258	+86	80°									
17.8	8.25	+1323	+62	80°									
18.8	8.20	+1385	+48½	80°		+42½							
19.8	10.20	+1433½	+49	80°		+42½							
20.8	8.20	+1525	+54	78°									
21.8	8.20	+1579	+56	78°									
22.8	8.25	+1635	+48½	78°		+39½							
23.8	8.20	+1683½	+51½	74°		+46½							
24.8	10.15	+1735	+50	74°		+46½							
25.8	8.15	+1760											

Watch No. 15 Property of T. B. Starr. Howard Maker, # 62, 615

Date	Time	Error Watch	Rate	Temp	Ba	Rate for 24 hrs	Date	Time	Error Watch	Rate	Temp	Ba	
20.7	11.30	-42					25.8	8.15	-09	-03	74°	Bu	-2¾
21.7	8.25	-42¾	+1¼	78°	DD		26.8	10.00	-12	-03	-	-	
22.7	10.05	-43	-½	78°	-		27.8	8.20	-15	-03	-	-	-3¼
23.7	8.25	-41	-2	75°	-	-2¼	28.6	8.20	-18				
24.7	8.20	+153¾	+104¾	65°	DU								
25.7	8.20	-26	stopped	35°	-								
26.7	8.20	+07½	stopped	65°	-								
27.7	8.20		stopped	35°	-								
28.7	8.140		stopped	35°	-								
29.7	10.00		stopped	35°	-								
30.7	8.20	+25½	+5½	60°	-								
H 31.8	8.25	+31	+5½	10°	-								
B. 1.8	8.20	+31½	-3	10°	-								
H. 2.8	8.20	+28½	+½	80°	-								
3.8	8.15	+29	-½	80°	-								
4.8	8.15	+25	-3½	80°	DU								
5.8	9.30	+21½	+½	80°	-								
6.8	8.15	+22	-2	80°	Bu								
7.8	8.25	+20	-2¾	76°	DD								
8.8	8.20	+17¼	-½	78°	DD								
9.8	8.15	+17	+4	78°	DU								
10.8	8.15	+21	+6½	76°	DU								
11.8	8.10	+27½	-2	77°	DU								
12.8	10.00	+25½	-2	76°	DU								
13.8	8.15	+23½	-2½	76°	DU								
14.8	8.20	+21	-2	76°	-								
15.8	8.20	+19	-2	77°	-								
16.8	8.20	+17	-3	80°	-								
17.8	8.25	+14	-3	80°	-								
18.8	8.20	+11	-2¾	80°	-								
19.8	10.20	+08½	-2¾	80°	-								
20.8	8.20	+06	-3	80°	-								
21.8	8.20	+03	-04	78°	-								
22.8	8.25	-01	-02½	75°	-								
23.8	8.20	-03½	-02¼	76°	-	-3¼							
24.8	10.15	-06	-03	74°	-	-3¼							
25.8	8.15	-09											

Watch No 16 Property of T. B. Stow Andermain number # 13,266

25

Date	Time	Error Clock	Rate	Temp	Bal	Auto ff. w.w.
20.7.	11.30	-8½				
21.7	8.25	-7	+1½	78°	DU	+1¾
22.7	10.05	-7	0	78°	DU	
23.7	8.25	-7½	-½	78°	DU	
24.7	8.20	-9½	-1¾	65°	DU	
25.7	8.20	-13	-3½	38°	-	
26.7	8.20	-16	-3	45°	-	
27.7	8.20	~~-21~~	-5	35°	-	
28.7	8.40	-27½	-6½	35°	-	
29.7	10.00	-34½	-7	35°	-	-6¾
30.7	8.20	-38½	-4	38°	-	-4¼
W 31.7	8.25	-40½	-1½	100°	-	
R 1.8	8.20	-43½	-3½	105°	-	
W. 2.8	8.20	-47	-3½	100°	-	
3.8	8.15	-44½	+2½	80°	-	
4.8	8.15	-46½	+1¾	80°	-	
5.8	8.20	-39½	+5½	80°	DU	+5½
6.8	8.15	-36½	+3½	80°	-	
7.8	8.25	-36	+½	80°	DU	
8.8	8.20	-40	-4	76°	DU	
9.8	8.15	-42	-2	78°	DU	
10.8	8.15	-42	0	78°	DU	
11.8	8.10	-43	-1	76°	DU	
12.8	10.00	-42½	+0½	77°	DU	
13.8	8.15	-42½	-½	78°	DU	
14.8	8.20	-42½	+½	78°	DU	
15.8	8.20	-43	-½	76°	-	
16.8	8.20	-45	-2	79°	-	
17.8	8.25	-45	0	80°	-	
18.8	8.20	-44	+1	80°	-	
19.8	10.20	-44½	-½	80°	-	
20.8	8.20	-45	-½	80°	-	
21.8	8.20	-44½	+½	80°	-	
22.8	8.25	-45	-½	79°	-	
23.8	8.20	-47	-2	79°	-	
24.8	10.15	-46½	-1½	76°	-	
25.8	8.15	-48	+½	76°	-	

Date	Time	Error Clock	Rate	Temp	Bal	Auto ff. w.w.
25.8	8.15	-48	-01	74	DU	
26.8	10.00	-49	+02	-	-	+2½
27.8	8.20	-47	+01	-		
28.8	8.20	-46				

Watch No. 17. Property of T. B. Starr. Waltham G. # 2642, 805.

(26)

Date	Time	Error of Clock	Rate	Temp	Ba	Error of Clock 8a. 24th	Date	Time	Error of Clock	Rate	Temp	Ba	
20.7.	11.30	-28½	-16½	72°	30	-18¾	25.8	8.15	-119	-09	74°	30	-8½
21.7	8.25	-44¾	-9¾	78°	-	-9	26.8	10.00	-128	-09	-	-	-8½
22.7	10.05	-52½	-6½	78°	-	-7	27.8	8.20	-136	-08	-	-	
23.7	8.25	-61					28.8	9.20	-144				
24.7	8.20	-63	-2	80°	30								
25.7	8.20	-66	-3	85°	-								
26.7	8.20	-68½	-2½	85°	-								
27.7	8.20	-74	-5½	85°	-								
28.7	8.40	-85	-11	85°	-								
29.7	10.00	-95½	-10½	85°	-	-9							
30.7	8.20	-102	-6½	85°	-	-7							
H 31.7	8.25	-119	-17	100°	-								
1.8	8.20	-129	-10	100	-								
H. 2.8	8.20	-146	-17	100°	-								
3.8	8.15	-154	-8	80°	-								
4.8	8.15	-163½	-9½	80°	-								
5.8	9.30	-180	-16½	80°	30	-15¾							
6.8	8.15	-196	-16	80°	-	-17							
7.8	8.25	-205½	-9¾	80°	30								
8.8	8.20	-218	-12½	78°	30								
9.8	8.15	-234	-16	78°	30								
10.8	8.15	-244	-10	78°	30								
11.8	8.10	+09	stopped	78°	30								
12.8	10.00	+0½	-9½	78°	30	-8							
13.8	8.15	-9	-9½	78°	30	-10¼							
14.8	8.20	-18½	-9½	78°	30								
15.8	8.20	-28	-9½	78°	-								
16.8	8.20	-37	-9	79°	-								
17.8	8.25	-46	-9	80°	-								
18.8	8.20	-55½	-9½	80°	-								
19.8	10.20	-65	-9½	80°	-	-9							
20.8	8.20	-73	-8	80°	-	-8¾							
21.8	8.20	-82½	-9½	80°	-								
22.8	8.25	-91½	-9	78°	-								
23.8	8.20	-100	-8½	78°	-								
24.8	10.15	-111½	-11½	78°	-	-10¼							
25.8	8.15	-119	-7½	78°	-	-8¾							

39) 5-10.5 - 39 120 1.3.5-U | 1309

5-3) 2129.75 | 4018 97 53 745

Watch No. 18 Property of T. B. Starr Nattham C. N. 228, 1-314

Date	Time	Error by Clock	Rate	Temp	Ex	Rate for 24 hrs	Date	Time	Error by Clock	Rate	Temp	Ex	Rate for 24 hrs
20.7	11.20	-28"	-8	78°	DU	-9¼	22.8	11.35	-901	-27	75°	..	-31¼
21.7	8.25	-36	-9½	78°	DU	-9	23.8	8.20	-928	-28	76°	..	-26
March 22.7	10.05	-465¼					24.8	11.15	-956	-28	76°	..	
								10.45	-1000	-4.4	76°	DU	
23.7	8.25	-58¼	-13	78°	DU	-14	25.8	8.15	-1025	-25	74°	DU	-28
24.7	8.20	-664	-7¾	45°	DU		26.8	10.00	-1057	-32	74°	..	-29¾
25.7	8.20	-80	-13¾	38°	..		27.8	8.20	-1084	-27	74°	..	-29
26.7	8.20	-96	-16	45°	..		28.8	8.20	-1110	-26			
27.7	8.20	-111¼	-15¼	35°	..	-17½							
28.7	8.40	-124	-12¾	35°	..								
29.7	10.00	-142¼	-18¼	35°	..	-15¾							
30.7	8.20	-157	-14¾	35°	..								
# 31.7	8.25	-176¼	-19¾	100°	..								
April 1.8	8.20	-19	157¼	80°	..								
# 2.8	8.20	-35	-16	100°	..								
3.8	8.15	-49	-14	50°	-								
4.8	8.15	-69	-20	50°	-								
5.8	9.20	-112¾	-43¾	80°	DU	-43¾							
6.8	8.15	-158¾	-44	80°	..	-46¼							
7.8	8.25	-177	-19¼	80°	DU								
8.8	8.20	-201	-23	76°	DU								
9.8	8.15	-216	-15	78°	DU								
10.8	8.15	-267¼	-51¼	78°	DU								
11.8	8.10	-295	-27¾	76°	DU								
12.8	10.00	-314	-19	80°	DU	-17¾							
13.8	8.15	-336¾	-20¾	78°	DU	-22¼							
14.8	8.20	-352	-19¾	80°	DU								
15.8	8.20	-377	-25	76°	..								
16.8	8.20	-401	-22	78°	..								
17.8	8.25	-423¼	-22½	78°	..								
	9.35	-426¼	-3		..								
18.8	8.20	-423¼	+2.9	80°	..	-DU							
19.8	10.20	-453	-29½	80°	..	-27¾							
20.8	8.20	-479¾	-26¾	82°	..	-27¾							
)	12.05	-502	-32½										
21.8	8.20	-522	-20	80°	..	-23¾							
22.8	8.25	-557	-36	78°	..								
	11.35	-901	-43	78°	..								

Received 7 Watches from Mr T. B. Starr of N.Y. about the 12th July. Wanted to communicate with Mr Ward about these. On receipt of letter of the 19th July from Mr Ward saying that he wished these tested took them out of the safe. As 5 of them had gold cases, requested Mr Starr to remove these and replace them with glass ones. This he did on the 20th.

The Watches he left in our charge are as follows

No.	Our Local Number	Maker	Maker's Number	Case
1	12	Non Mag Co	55821	Watchmakers
2	13	T. B. Starr	Under face plate	do.
3	14	Elgin Co	942,025	do
4	15	Howard	62,615	do
5	16	Audemars	~~2,142~~ 13,266	do
6	17	Am. Wat. Co	2,642,805	Golden.
7	18	Am. Wat. Co	225,434	Silver.

The first and last, our nos. 12 and 18 are for magnetic test. The others are for rate comparisons only.

Bordier Voltmeter repaired with 4 metres (roughly) of platinum iridium wire 0.002" Res. 700 ω.

30° no indicate	56.3 volts
40°	67
50°	70.5
60°	88.5
70°	90.5
80°	97
90°	107
100°	111.5
110°	125.5
115°	129

Calculation for the length and weight of wire we shall need for the Edison Voltmeter, and also for the sheet shunt of Platinoid.

We know that we shall need some 50 metres of wire 0·018" diam (0·045 cm) see book 2 page 16. for each voltmeter. The area of this wire is 0·00159 sq. cms which × 5000 = $1.59 \times 10^{-3} \times 5 \times 10^{3}$ = 7·95 sq. cms. volume. The spec. gr. being 8·5 makes the mass 67·6 grammes. = 0·15 lbs: so that, it should be enough for 6½ voltmeters.

1000 amperes or 100 units of current flowing through a strip of platinoid t centimetres thick and w centimetres wide, gives an average current of $\frac{100}{tw}$ per sq. cm. of section. The strip for every cm. of its length will have reflecting the edge 2w sq. cms of surface. so that the surface per sq cm will be $\frac{2w}{tw}$ or $\frac{2}{t}$. Now neglecting convection the energy developed by the current will be

$$\frac{4 \cdot 03 \times 10^{4} \times 100^{2}}{t^{2}w^{2}} \text{ or in Heat units}$$

$$\frac{4 \cdot 03 \times 10^{4} \times 10^{4}}{4 \cdot 16\, t^{2}w^{2} \times 10^{3}} = \frac{40 \cdot 3}{4 \cdot 16\, t^{2}w^{2}} = \frac{9 \cdot 69}{t^{2}w^{2}}$$

The heat radiated per sq. cm = $\frac{2\theta \times 2 \times 10^{-4}}{t}$ per cm.

$\therefore\ 9.69\, t = 4\, t^{2}w^{2}\theta \times 10^{-4}$ assume $\theta = 1°$ C.

$\therefore\ 2.42 \times 10^{4} = t\, w^{2}\theta$

$\therefore\ w^{2}t = 2.42 \times 10^{4}$

$\therefore\ w^{2} = \frac{2.42 \times 10^{4}}{t}$

$\therefore\ w = \frac{1.55 \times 10^{2}}{\sqrt{t}}$

1/16" = 0·0625" = 0·159 cms. $\sqrt{159}$ = 0·4

$6.56 \div 0.4$ = 3.9 × 10 = 39 cms wide = 1/16" wide

Every cm. of length will have an area of $6'' \times \frac{1}{16}$. $= \frac{15.24 \times 0.159}{}$ sq. cm $= 2.423$ sq. cm
or 2.423 c.c. volume $\times 9.5 = 20.6$ grammes.
so that each inch will weigh $20.6 \times 2.54 = 52.3$ grammes $= \frac{52.3}{454.6} = 0.115$ lbs. so that 9" go to the lb. approx.
The res. of one strip is $\frac{4.03 \times 10^{4}}{2.423}$ res. per cm.
$= 1.66 \times 10^{4} = 1.66 \times 10^{-5}$ ohm.
The res. of 30 cms will then be 4.98×10^{-5}
$= 0.000049$ ω the difference of potential between the ends at 40 amps. current $= 5 \times 10^{-4} \times 4 \times 10^{1}$
$= 20 \times 10^{-3} = 0.02$ volt. To get 0.05 volt requires 75 cms. $= 30''$
25 strips of 30" $= \frac{25 \times 30}{9}$ lbs. roughly $= \frac{750}{9} =$ 83.3 lbs say 84 lbs @ 45 ct $= \$37.80$.

Siemens Alternating Dynamo.

All the 16 magnet coils (8 on each circle) in series Res. 1.3 ω.

a and d are connected to 1.
b goes to 2
c goes to 3

Resistance of plating armature.
Pole Insulated 7" pulley 5.28 volts
Pole Connected through 1.4 ω

$\frac{4.9}{.38}$: $4.9 : x :: 1.4$
$x = 0.1$ ω

Some (bad contact - evidently) in circuit.

Physiological - Experiments Continued

Saturday 21st July.

Yellowish brown bitch — Weight 41½ lbs.
Length 37
Height 22
Reg. 8700

Tried effect of induction coil supplied by 5 volt dynamo. Dog bandaged on opposite leg as usual. 1st coil. Small one ½" spark.

21.05. Current on for 7 seconds.
Dog struggled but unhurt.
Took 2nd Coil that used by Schulze Berge for his vacuum depositing. 1½" spark full.

21.13. Current on for 5 second.
Dog struggled violently but unhurt.

21.25. Took large black induction coil giving about 1" spark very vivid one. Contact made & broken by mercury interrupter. Contact made for 5 secs. Dog struggled but unhurt. Placed wet pads under and in the ears, and used these as electrodes. Contact made as before. Dog struggled violently and got free quite unhurt though much excited. Obliged to discontinue experiments, for want of power.

Employed Siemens alternating dynamo making 1080 revs. per min. = 18 revs. per sec. = 18 × 8 × 2 = 288 alternations per sec.

First supplied its field magnets from the plating dynamo, but found the field quite insufficient, only about 40 volts from the set.

Used the transformer described on page 9 with some 100 in the primary cct. and some 1500 in the secondary, some four times the number of turns.

Cardew voltmeter employed for measuring voltage either directly or in cct. with lamps. Primary cct. voltage about 123 with some 10 amperes in the field circuit. Secondary cct. 125 volt when 6 lamps hot in series with voltmeter. Say each lamp has 200 ω = $\frac{1200 + 700}{700} \times 125$ = 340 volts.

Same dog as that mentioned in Saturday's experiment on the preceding page. Resistance between leg bandages as usual 14,000.

21.15. Mr Batchelor present.

Voltage before making contact about 140 volts with 6 lamps = $\frac{19}{7} \times 140$ = 380 volts.

21.25 Made contact for 5 secs: in primary cct. secondary on dog and voltmeter cct. as shunt. Voltage 191 volts with 6 lamps = 247
reproduced by 136 - - 3 - = 252
by mean say 250 volts.

Dog uttered no sound, muscles convulsed, but no struggling and died almost instantly. No struggling after current off beyond muscular twitching.

1 B.C. thro' 0.5 f = 112.0
112.0
@ 21°C = 1.43114 volt. 112.0
112.

Mean temp. of the room 21.39° C.

After observation:

1 B.C. thro' 0.5 f 114.5
115.0
@ 22.1°C = 1.4301 115.1
115.2
114.95

$$\mathcal{L} = \frac{d \times 0.715375 \times 5253 \times 10^{5}}{113.475 \times 46.57} = 71.1107\,d$$

Resistance results 19th July 1888 0.7f J.B.D.

Time	Volts	Ohms	Osc. B.	Amperes	Thermo	Corrected	Adjusted Mean	$\mathcal{L}$
9.50	118.2	32.4298	Earlier 0.1	197.6	10.0	10.0	9.6	683
.54	118.5				9.	9.0		
10.00	118.8				9.8	9.8		
.06	117.9	12.4307	0.2	375.2	18.	18.0	18.1	1287
.09	118.6				18.2	18.2		
.15	118.2	2.850	0.4	750.2	37	37	37.	2631
.17	118.8				37	37		
.27	118.2	103	7°.45'	1876	85.5	85.85	85.54	6083
.32	118.8		7°.47'		85.2	85.20		
.36	117.8	70.89	11°.35'	2811	115	115	115.6	8220
.39	118.2		"		116	116		
.42	119.3		"		115.8	115.8		
.46	118	52.078	15°.20'	3752	137.8	137.41	138.0	9813
.49	117.6		15°.15'		139	139.4		
.52	118.9		15°.25"		138.5	137.3		
.57	119.1	34.739	18°.55'	4690	182	187.6	187.9	10,802
11.01	118		18°.55'		182.5	182.1		
.06	117.3	32.147	22°.20'	5526	158.5	157.2	156.5	11,129
.10	117.5		22°.26'		157	156.7		
.14	117.2		22°.45'		158	156.5		
.24	117.1	23.072	28°.40'	7504	168.3	166.3	167.9	11,939
.28	117.1		"	"	167.5	167.5		
.32	119.0				168.0	166.0		
.42	116.6	17.29	34°.15'	9380	172.5	173.2	173.	12,302
.46	117.1		34°.20'		173	173.1		
.50	115.9		34°.15'		172	172.6		
13.13	115.3	13.508	39°.20'	11256	178	178.1	179	12,728
.20	116.1		39°.15'		179	179.7		
.25	116.4		39°.10'		178	179.2		
.32	116.6	11.517	43°.45'	13152	183.5	183.4	183.2	13,930
.38	116.6		43°.45'		183	182.9		
.49	116.5	8.019	47°.20'	15008	186.9	186.9	186.8	13,283
.53	116.6		"		186.5	186.6		
14.23	116.1	—	50°.25'	16884	188.5	188.8	189.97	13508
.27	115.3		50°.20'		190.5	190.8		
.30	116.3		50°.25'		190	190.3		
.35	115.7	5.446	53°.50'	18760	192.3	192.3	192.2	13,667
.40	116.1		53°.50'		192	192.		
.61					R.D. 0.62			
.64					Current off	R.D. 0.7		

Plating dynamo now gives 5·60 volts at normal speed with 7" wooden pulley. At first when at work on 1·35 v the P.D. at brushes fell to 5·45 indicating 0·037 v in the armature and brushes. After cleaning the brushes and commutator the P.D. rose to 5·57 v indicating 0·015 v, and necessity for further cleaning

---

Res: of Gardner voltmeter = 697·5 v @ 50° F

3 Resistances wound to put in circuit with it in order to use it with higher voltages —

Some 36 feet of the same platinum iridium wire 0·002" = 0·00508 cm.

1st length	702 v		
2nd "	716	=	14·18 ohms
3rd "	703	=	21·21 "

The indications of the instrument were checked again as follows:—

30°	54·5 volts
40°	62·7 "
50°	74·5 "
60°	84 "
70°	90 "
80°	97·5 "
90°	106·5 "
100°	112 "
110°	119 "
118°	131 "

Tried the effect of current on the wire to ascertain its carrying capacity :—

at 0·2 amperes When checked up but no burning visible

0·3 " Wood work being charred not visibly but by sense of smell.

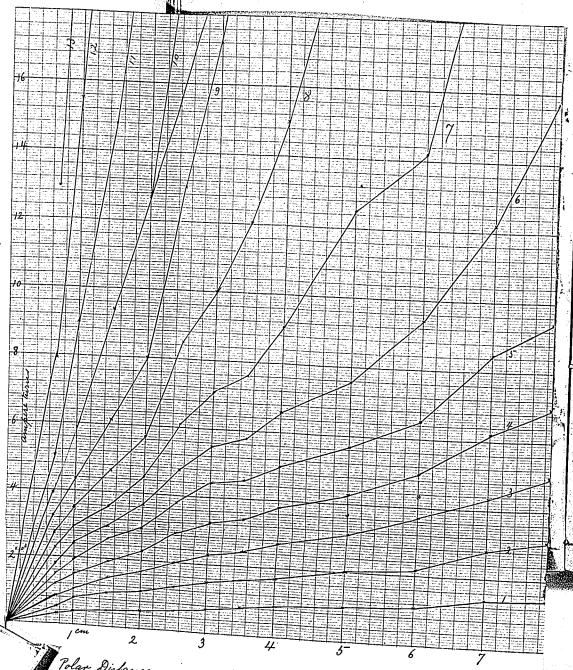
When current taken off wire partly tightened.

0·35 amp faint red heat. 0·5 amperes, this gave way down to low end

0·36 " Distinct red heat.

0·40 " Glowing red hot. 0·2 is the safe limit to employ.

0·45 " White hot, burning wood.



Pendulum Magnetic Results.

Since $\mathcal{L} = f(c\ d\ r)$

where c = current strength

d = interpolar dist.

r = magnetic resistance of iron

but $r = \phi(\mathcal{L})$

$$\therefore \frac{d\mathcal{L}}{dc} = \frac{f'\{c, d, \phi(\mathcal{L})\}}{dc} + \frac{f'\{c, d, \phi(\mathcal{L})\}}{dd}\frac{dd}{dc} + \frac{f'\{c, d, \phi(\mathcal{L})\}}{d\phi(\mathcal{L})}\frac{d\phi(\mathcal{L})}{d\mathcal{L}}\frac{d\mathcal{L}}{dc}.$$

The second term here vanishes and we have

$$\frac{d\mathcal{L}}{dc} = \frac{f'\{c, d, \phi(\mathcal{L})\}}{dc} + f'\{c, d, \phi(\mathcal{L})\}\frac{d\phi(\mathcal{L})}{d\mathcal{L}}\frac{d\mathcal{L}}{dc}$$

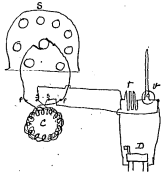
$$\text{or } \frac{d\mathcal{L}}{dc}\left\{1 - f'\{c, d, \phi(\mathcal{L})\}\frac{d\phi(\mathcal{L})}{d\mathcal{L}}\right\} = \frac{f'\{c, d, \phi(\mathcal{L})\}}{dc}$$

To more easily derive this equation let us make $\phi(\mathcal{L})$ constant by keeping to single constant value of $\mathcal{L}$, in which case the equation becomes

$$\frac{d(\mathcal{L})}{dc} = \frac{f'\{c, d\}}{dc}$$

The accompanying sheet plots the relation between the exciting power (ampere-turns $\times 10^3$) as ordinate and Interpolar distance as ordinate. The different lines correspond to the different constant values of $\mathcal{L} \times 10^3$. This not gives the curve for 1000 lines per sq cm. Allowing for dispersion of the lines at large interpolar distances the curves are approximately straight lines. That is to say $X = ad + b$ where X is exciting force d is the interpolar dist a a constant and b a constant depending on the magnetic resistance

The curves are incorrectly drawn through the origin, and the sheet will require revision



S Siemens machine making about 1050 revs per min. excited by No 20 Machine.

C Converter

r inductancebox resistance

v Bardeen voltmeter

D Dog.

Evening Tuesday 24th July. Mr Brown present.

Foxhound Dog Weight 56 lbs:

Length tip of nose to base of tail 39"

Height 23"

Res: between bandages on legs 27,500

Bandages of wet cotton waste on opposite fore and hind legs.

Used alternating Converter, described previously

Voltage in 2ndary ct: before closing dog circuit 181 volts.

21.50 Contact in primary ct. for 5 secs.

Indicated voltage 158 in 2ndary.

Result:- Dog motionless and silent. No struggling after current off. Dropped dead almost instantly.

Red Setter Weight 59 lbs:

Length tip of nose to base of tail 39"

Height 24"

Res. 5000 ω. between bandages on legs.

Volts before contact 120 in 2ndary

21.53 Contact in primary ct for 5 seconds.

Indicated volts 99.

Result dog gave one slight yelp while current on, after removal of current barked, dropped and struggled, but recovered in about 30 secs: Evidently hurt.

22.22. Volts before contact 182 in 2ndary

Contact for 5 seconds. Indicated voltage 114.

Result:- dog) silent during contact but at cessation barked and struggled violently. Bitches loose partly and got out of box.

Much hurt and exhausted.

22·30 Voltage before current on dog 190 in 3rd 37.
Contact for 5 secs: Voltage indicated 146.
Result:- Dog silent during shock but howled and struggled afterwards, unable to stand, long.

22·33 Voltage before current applied 204.
Contact for 5 secs: Voltage indicated 176.
Result:- Dog silent during contact but howled feebly afterwards. Panting and sweating very much.

22·36 Voltage before current applied 260.
Contact for 5 secs: Voltage indicated 188.
Dog silent and motionless died without struggle.

Epitome of Physiological Experiment

No. of Expt.	Description of Dog	Length in	Height in	Weight lbs.	Electrodes applied to	Electrode contact	Current employed	Voltage on dog before shock	Duration of current	Amount of current in dog	Number of applications of shock	Time elapsing before death
1	Small black terrier	–	–	–	R. ear & L. hind leg	Tinfoil	Direct	800	2	3/4 L	1 Fatal	Second min
2	Terrier	–	–	–	do.	Bare	alternate 25	800	3	—	3 Fatal	within 30 sec
3	Fox terrier	26"	13"	13½	do	Tinfoil	Direct	1000	Momentary	0·25	5 Fatal	in 2 mins
4	Bull dog	37"	21"	46½	do	Tinfoil	alternate 25	800	2½	0·1	1 Fatal	in 15 secs
5	Black Terrier	33½"	23½"	39	do	Tinfoil	Direct	1000	2½	0·37	6 Not fatal	—
6	Black mongrel	35"	21"	55	do.	Tinfoil	alternate 25·3	870	3	—	3 Fatal	in 90 secs
7	Yellow "	28½"	18"	35	do	Tinfoil	Direct	500	4	0·025	0 Fatal	in 5 mins
8	Bull terrier	46"	23"	47	Head	Tinfoil	alternate 16	300	4	—	1 Not fatal	—
							"	1200	4	1·2	3 Fatal	in 15 secs
9	Yellow mongrel	37"	22	41½	R. Fore & L. hind leg	Tinfoil	Alternate 25·3	250	5	—	0 Fatal	at once
10	Terrier	30"	23"	56	do	Tinfoil	do.	158	5	—	0 Fatal	at once
11	Setter	34"	26"	59	do	Tinfoil	do	188	5	—	0 Fatal	at once

Cell no 1

Date	Time	Hour	B.Bent	EMF	I.R.	G.		
26.7.	9.0	0	1.704	1.164	0.193			
	9.30	½	0.930	0.548	0.089			
	12.00	3	0.936	0.570	0.104			
	18.00	9	0.012	0.360	0.073			
27.7	8.0	23	0.992	0.546	0.050			
	12.00	27	0.980	0.534	0.048			
	18.00	33	0.980	0.546	0.057			
28.7	8.00	47	0.936	0.469	0.055			
	18.00	57	0.848	0.470	0.055			
30.7	8.00	95	0.840	0.467	0.055			
	The weight of the zinc after test was jointly 150.0g 4.25oz. Loss 15.5g 12.5g.							

Cell #2

Date	Time	Hour	B.Bent	EMF	I.R.	G.		
26.7	9.0	0	1.760	1.223	0.195			
	9.30	½	0.864	0.700	0.310			
	12.00	3	0.810	0.666	0.322			
	18.00	9	0.888	0.660	0.243			
27.7	8.00	23	0.900	0.588	0.135			
	12.00	27	0.900	0.588	0.120			
	18.00	33	0.920	0.540	0.086			
28.7	8.00	47	0.848	0.522	0.115			
	18.00	57	0.752	0.499	0.064			
30.7	8.00	95	0.732	0.468	0.129			
	The weight of the zinc after test was jointly 150.0g 4.25oz. Loss 16.5g 13.5g.							

Wednesday 25th July

38

Received 40 packets of Fitch's "perfect" battery excitants, and 8 carbon plates.

Made up 2 cells according to his directions as follows:—

In each cell 23 × 15 × 20 cms deep, 4 carbons each 23 × 15 × 1.3 cm and 3 blocks amalgamated Zinc 19 × 16 × 0.6 cm clamped together and separated by 0.8 of wooden blocks. The weight of the zinc in cell no 1. was 154.65 oz = 4380 grammes. That in cell no 2 150.25 oz = 4400 . The height of the solution was about 17 cms and 1 gallon in volume = 3780 c.c. absorbing 8 packets of excitant. The active surface of zinc is about 1350 sq. cms.

These cells were set to work at 8.30 on 0.5 ω platinoid.

A preliminary experiment was made with a frog to ascertain the sensibility of the muscular nervous tissue to the direct current. The result was that 20 microamperes was the smallest current that appreciably affects the limb 2 volt the limb and 100,000 ω in closing the circuit. This result having to be regarded as only preliminary.

Mr Edison respiration, sitting in chair thinking and speaking 16. 27. 7. 85 about 40 per min.

Thursday 26th July.

Received Condenser of 4 capacity from Mr W Marshall to test. With following results.

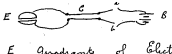
Plans of Marshall Condenser compared with Elliotts

1	2	3	4	5	6	7	8	9	10	11	12	Marshall
0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	1·0	2·0	

1	2	3	4	5	6	7	8	9	10	11	12	Elliott
0·001	0·002	0·002	0·005	0·01	0·01	0·02	0·05	0·1	0·1	0·2	0·5	

Comparison by Sir W. Thomson method using bridge + std. labile astatic galvo:

No. of Readings	Marshall plates	Pot.	Elliott plates as standard	Pot.	Balance in bridge	Ratio	Value	Discrepancy %	
(1)	1 to 10	1·0	1 to 12	1·0	2007.5	1·0037.5	1·0037.5	0·375	
(2)	11	1·0	-	1·0	2005.	1·0025	1·0025	0·25	
(3)	12	2·0	-	1·0	3995	1·9975	1·9975	0·25	
(4)	1 to 5	0·5	1 to 11	0·5	2007	1·0035	0·5017	0·35	
(5)	1 to 5	0·5	12	0·5	2005	1·0025	0·5012	0·25	
(6)	6 to 10	0·5	12	0·5	2006	1·0030	0·5015	0·30	
(7)	1	0·1	1 to 8	0·1	19964	0·9982	0·0998	0·18	
(8)	1	0·1	9	0·1	1997	0·9985	0·0999	0·15	
(9)	1	0·1	10	0·1	1993	0·9965	0·0997	0·35	
(10)	2	0·1	9	0·1	1996	0·9980	0·0998	0·20	
(11)	3	0·1	9	0·1	1997	0·9985	0·0999	0·15	
(12)	4	0·1	9	0·1	1993	0·9965	0·0997	0·35	
(13)	5	0·1	9	0·1	2003	1·0015	0·10015	0·15	
(14)	6	0·1	9	0·1	1993	0·9965	0·09965	0·35	
(15)	7	0·1	9	0·1	2003	1·0015	0·10015	0·15	
(16)	8	0·1	9	0·1	1991	0·9955	0·09955	0·45	
(17)	9	0·1	9	0·1	1990	0·9950	0·09950	0·50	
(18)	10	0·1	9	0·1	2000	1·0000	0·1000	0·00	
			Sum 4·04				0·9982		



E Quadrant of Electrometer
C Condenser with armatures joined to same
B 5 Gravity cells
a and b wire contacts pulled asunder at 60" electrification: No grounding on electrometer or condenser.

Loss of Charge test quadrant Electrometer 5 Gravity cells. all capacity 4 ↑.
Charged for 60 secs. at 16.12'

16.13.	Disconnected	Full potential	305.7
.14	after 1'	—	304.
.15	- 2'	—	303.
.16	- 3'	—	302
.17	- 4'	—	301
.18	- 5'	—	300
17.13	- 60'	—	274

Loss of charge after 5' = 5.7 = 1.9 %.

Same test of Elliott condenser. 1'

17.31	Charged.		
.32	Disconnected	Full potential	306.5
.37	after 5'	—	297.5
18.17	Loss of charge after 5'	= 7.0 =	2.3 %.
	after 45'	—	268

Insulation of 4 ↑ condenser =

$$\frac{2.06 \times 60}{4 \times \log \frac{306.7}{274}} = \frac{156.36}{4 \log 1.1192} = \frac{156.36}{4 \times 0.0475085} = \frac{1583.6}{.190034}$$

$$\frac{15.636 \times 10^{3}}{1.90034} = 8228\ \Omega.$$

Time of fall to half charge $= \frac{0.30103 \times 60}{0.0475085} = \frac{180.618}{4.7585} = 380'$

Insulation of 1 ↑ Condenser =

$$\frac{2.06 \times 145}{4 \times \log \frac{306.5}{268}} = \frac{6.5187 \times 145}{\log 1.1362} = \frac{293.17}{0.055454278} = \frac{29317}{5.54255} = 5286$$

Time of fall to half charge $= \frac{0.30103 \times 145}{0.055454} = 2444'$

The same precautions were not used to thoroughly clean the Elliott Condenser, as were taken with the Marshall Condenser

1 b.b. 0·54 = 109·7
109·3
109·8
109·0
109·45 @ 23.8° C.

After Observations

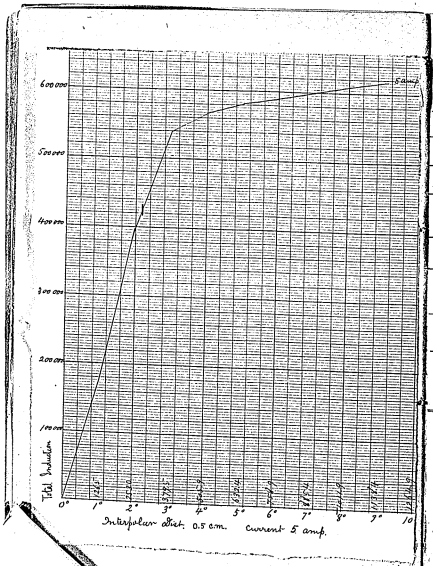
109·5
109·4
109·4
109·43 @ 27.1° C

Mean = 109·44

Rec: of Nbrick of magnet 2·509
" S " " 2·4155
Sum 4·9644

$$D = \frac{d \times 0{\cdot}7132 \times 5330 \times 10^2}{109{\cdot}44 \times 46{\cdot}57} = 74{\cdot}594\,d.$$

Time	Volts	25th Phase	Inst. b	1885 Phase	Phase	Correction	Mean Adjusted	δ	401 Y.P.
10.35	115·9		0·1		12·5	12·5	12·8	95·5	
·39	116·1		0·1		13·0	13·1			0·5
·43	116·3		0·2		22·0	22·0			
·47	116·7		"		21·0	21·0	21·3	159·9	
·49	116·9		"		20·5	20·5			
·53	116·3		0·4		44·9	44·9	44·55	332·3	
·56	116·1		0·4		44·3	44·3			
11.04	115·9		7°·45'		95·5	95·9	95·65	713·5	
·06	116·5		7°·45'		95	95·4			
·10	115·9		11°·25'		124·4	124·4	123·75	923·1	
·14	115·7		11°·25'		123·0	123·1			
·17	115·		15°·15'		143	143·4	143·15	1067·8	
·20	116·4		15°·15'		142·5	142·9			
·27	116·2		18°·45'		153·	154·3	153·7	1146·5	
·30	116·0		18°·55'		152·8	153·1			
·35	113·		22°·10'		158·5	160·4	159·55	1190·0	
·40	115·		22°·20'		159·0	158·7			
·45	114·5		28°·40'		166·	166·0	165·85	1237·0	
·50	115·1		28°·45'		165·8	165·5			
13.25	115·8		34°·30'		173·8	173·6	173·25	1292·3	
·30	116·5		34°·25'		173	172·9			
·34									0·23
·37	113·2		39°·20'		177·0	177·0	176·65	1317·7	
·42	114·5		39°·20'		176·0	176·0			
·49	114·7		39°·20'		176·3	176·3			
·54	115·3		43°·45'		180·4	180·4	180·45	1346·0	
·56	114·9		43°·40'		180·5	180·5			
14·01	113·8		47°·35'		184·2	184·2	184·1	1373·2	
·05	113·4		47°·30'		184·0	184·0			
·08	113·5		51°·30'		187	186·8	187·05	1395·2	
·11	113·4		55°·45'		187·3	187·3			
·15	113·2		53°·30'		189·0	189·0	189·1	1410·6	
·19	113·3		54°·55'		189·2	189·2			
·20									Base Adj
·22		Current	off						



Amplitude series of Magnetic Induction

(12)

Time	Volts	Amplitude Turns	Amplitude Gauss	Field Gauss	Relative Magnetic Gauss	Adjusted Mean	Magnetic Fl	Total Fl	Angle ÷ 12
									0.42
14.36	113.4		34°.26′	51	51	51.2	381g	177,890	1°
.40	113.8		34°.26′	51.4	51.4				
				113.5	113.5				
.47	113.8		"	114.	115.0	114.25	8522	396,940	2°
.50	114.0		"						
.53	113.9		"	155.5	155.5	155.25	11,581	539,310	3°
.55	113.8		"	155.	155.				
.58	114.9		34°.23′	166	163.97	163.5	12,196	567,900	4°
15.05	113.8		34°.18′	163	163.03				
.07	113.8		34°.15″	166	166.09				
.10	113.8		34°.20′	168	168.03	167.49	12,494	581,810	5°
.13	113.0		34°.25″	168	168.38				
.16	113.6		34°.20′	169.5	169.5	170.29	12,703	591,530	6°
.19	113.5		"	171.0	171.0				
.22	111.5		34°.5′	173.5	173.34				
.26	112.2		34°.10′	171.5	171.67	172.5	12,867	599,180	7°
.29	112.5		34°.15′	172	172.09				
.34	109.9		32°.24′	175	175.014	175.29	13076	608,950	8°
.37	103.1		34°.26′	175.5	175.512				
.40	113.2		34°.20′	177	177.04	177.61	13248	616,920	9°
.43	112.8		34°.10′	178	178.18				

The area swept out is

$$\frac{\varphi^\circ}{360^\circ}\left\{\pi\left(124.5^2 - 90.05^2\right)\right\} = \frac{\varphi\pi}{360}\left\{15500.3 - 8253.7\right\}$$

$$\frac{\varphi\pi}{360}\left\{7246.6\right\} = \frac{22766}{360}\varphi = 63.24\varphi$$

Barometer and attached thermometer daily readings at Noon (Aug)

Date	Inches	cms.	Temp.	Weather	Clouds	
27. 7. 88	29.929		79°	Rain	Nimbus.	
31. 7. 88	29.882		75°	Fine	Cirro Cumul	
1. 8. 88	29.882		77½	Variable	Cirrus & Nimb	
2. 8. 88	29.952	76.07	75°	Fine	Cloudy.	
3. 8. 88	29.924	76.03	76°	Fine	Heavy clouds	
4. 8. 88	29.766	75.62	81°	"	" cumulus	
6. 8. 88	29.794	75.67	79°	Cloudy +	Nimbus	
7. 8. 88	29.402	74.68	75°	Clearing	Nimbus.	
8. 8. 88	29.440	74.78	75°	"	"	

The accompanying curves shew the behaviour of 10 Grove cells arranged to work through the same external res. only differing in the quality of their zinc in which the proportion of mercury varied from 5 up to 14 %.

The weight of the zincs before and after the test were as follows grammes.

No.	5	6	7	8	9	10	11	12	13	14
Before	373.2	379.2	381.5	378	385	383.4	388	389.5	393.5	393.2
After	295.5	299.2	301.1	297.9	307.5	298.9	306.9	307.9	307.2	308.7
Loss	77.7	80.0	80.8	80.1	77.5	84.5	81.1	81.6	86.3	84.5
Order	2	3	6	4	1	8	7	5	10	9

Showing that those cells which had done the most work (namely 5 6 + 7 had consumed less zinc than the others.

Another set of zincs was placed in the battery solution so as to give no current but to allow local and chemical action to take place with following result. The test lasted from 11.20 to 14.30 and the vessel containing them became very hot

No.	5	6	7	8	9	10	11	12	13	14
Before Quiet	380.7	375.5	392.2	386.9	385.2	389.9	396.2	393.7	390.5	390.5
After Quiet	369.7	356.7	370.5	374.5	375	379.9	389.4	387	384.2	390.4
Loss	21.0	18.8	11.7	12.4	10.2	9.0	6.8	6.7	6.3	0.1
Order	10	9	7	8	6	5	4	3	2	1

Saturday 28th July.

Tested the accuracy of the barometer scale with the cathetometer as follows—

Common mark in centre of Barometer read by both telescopes

		Upper	649.32
			649.33
		Mean	649.325
By upper	64.9325		
" lower	60.4005	Lower	60.4008
			60.4009
		Mean	60.4005
Reduction of upper to lower reading	4.524		

Reading of bore point in well with lower telescope 22.3410
22.3411
22.3405
Reduction to upper telescope 4.524
26.8645

Reading of 71 Mark	97.868 − 26.8645	=	71.0035
72 "	98.870	=	72.0055
73 "	99.869	=	73.0045
74 "	100.8685	=	74.0020
75 "	101.869	=	75.0045
76 "	102.871	=	76.0085
77 "	103.870	=	77.0055
78 "	104.869	=	78.0045
			8) 39.5
	Mean Diff.		0.0049

So that the mean reading of the barometer is greater than the cathetometer distance by 0.0048 cms = $\frac{1}{50}$th of millimetre @ 75°F = 23°C

The glass cylinder case of the standard Electrometer was carefully washed and dried but it still refuses to hold a charge

Monday 30th July.

Examined in company with Mr Worthington a multiplex scheme of telegraphy invented by Mr Rogers of Washington.

Two large heavy flywheels about 18" in diam: carry eleven sectors mounted on a concentric inner circle. These sectors are maintained in communication through brushes and the line wire. The synchronism is maintained by the current sent at every revolution through the 11th sector which passes on to an induction coil & causes a spark to be visibly projected on the edge of the periphery of the fly wheel. If the wheels are in unison the spark will always be visible at or very near the same spot and this has to be attained by applying friction or rotating the contacts under personal supervision. The normal speed is 800 revs per min = a capability of 8000 signals per min = 133 per sec:

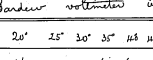
Took the highest speed attained = about 1150 revs. per min. Pointed out to the gentlemen present that though the apparatus was simple and ingenious it required continual personal supervision and that it would have to show itself superior to the Phelps printer or the Delany telegraph before it could supplant those instruments in use.

Took the following comparison of the Bardeur voltmeter with potentiometer.

Deg.	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°
Volts	46·1	52·1	57·0	61·0	67·0	70·8	75·6	80·4	83·6	89·6	94·6	99·0	102·4	107	110·4

Measurements and observations taken at the Exhibition ~~before~~ at the School of Mines Columbia College N.Y. before the N.Y. Board of Electrical Control.

Large black Retriever Mongrel Weight 76 lbs



Length tip to tip 65"
Dog very vicious + seemed will difficulty.
Tip nose to base tail 51"
Height 24"
Res. 15,300 Ω

14.53 First current (momentary) Volts at machine 300
Dog howled + struggled but not hurt
·57 do do Volts 400
·58 – – 500
15·02 do do amp 0·2 700
·09 do do – 0·45 – 1000
Dog violently struggling + howling at each shock but otherwise not hurt.
·25 Siemens machine excited by 100 volt Edison dynamo working into converter, volts before contact 500 by Bardeur
Contact made on dog 330. not allowing any
·10 for mean spread Dog howled while current on + struggled for a little time but then fell dead within 30 sec.
The suff. of the Loc. for Revenge of Guilty be Answered

Tuesday 30th July.

The following shews the result of a meter trial with pure zinc electrodes and pure zinc sulphate solution. Mr Sawai took the weights.

Plate No	Weight on the 29th July	Joint weight	Weight on the 30th July	Joint weight	Gain	Loss	Diff
A1	21.2342	44.0512	20.5590		0.6580	0.6752	-0.0079
C2	22.8169		23.4749				
A3	21.7793	43.7919	21.0921		0.6394	0.6872	+0.0041
C4	22.0126		22.6518				
A5	21.6737	43.3793	20.9952		0.6587	0.6755	-0.0086
C6	21.7056		22.3636				
A7	21.5789	43.6632	20.9925		0.6571	0.6864	-0.0037
C8	21.9839		22.6410				
A9	22.1016	43.0396	21.4277		0.6509	0.6739	-0.0092
C10	20.9379		21.5888				
A11	20.2062	41.4107	19.5392		0.6580	0.6670	0.0151
C12	21.2046		21.8626				
A13	20.5416	40.6726	19.8524		0.6421	0.6892	0.0061
C14	20.1312		20.7735				
A15	21.2791	42.3746	20.5948		0.6486	0.6843	0.0022
C16	21.0957		21.7643				
A17	21.5178	42.3198	20.8145		0.6627	0.7033	0.0202
C18	20.8023		21.4650				
A19	22.0525	42.1658	21.3440		0.6568	0.6885	0.0034
C20	20.1131		20.7699				
						68.205	·0288
						= 0.6821	·0036
						= 1.26%	

Tuesday 31st July

Took the sp. g. of the 4% - zinco with following result :-

		In air	In water	sp. g.
1st specimen	pure zinc	8.98	7.64	6.701
1st -	alloy	8.42	7.265	7.29
2nd -	pure zinc	12.145	10.385	6.9
2nd -	alloy	14.075	12.15	7.31

Temp: about 75°. distilled water.

$$13.6\,x + (1-x)\,6.8 = 7.3$$
$$\therefore \quad x = 7.35\% \text{ by volume}$$
$$= 13.7\% \text{ - weight.}$$

As less than 4% rather than more was expected, it is probable that the structure of the alloy does not admit of calculation in this way, the zinc appearing to be denser than in the pure crystalline state.

Wednesday 1st August.

Commenced winding a converter @ follows. ring of oxydized iron wire weighing 1.5 lbs = 24 oz = 680 grammes. #26 iron wire 0.018" covered with layer of tape. Over this the ext. diam = 8⅞". the int. diam 7⅜".

Over this #21. SWG was wound. 0.036" opened 0.03" bare

Four layers of about 581 turns each = 2905 say 2900 turns in all were layed on. the total res. being 6 ω. Above this an insulating layer of india rubber and then 13½ layers of #36 wire, 0.005" 0.122" = about 400 feet. The whole was then placed in melted paraffine wax & well taped.

Chartin
Envelope
N-880610

The opposite curve shews the exciting power necessary for different interpolar distances. And the upper ~~ex~~ curve shews roughly from that, the exciting power necessary to produce induction through the magnet at no interpolar distance or the reciprocal of the ~~conductivity~~ permeability of the iron.

Thursday 2nd August.

A set of different solutions was made up for Grenet batteries with the object of finding the best for the phonograph motor. The results are as follow.

Standard solution	5 lbs	Am. CrO_3	
# 15	15 -	Common H_2SO_4	
	40 -	H_2O	
	CrO_3	H_2SO_4	H_2O
# 16	5 lbs	20	40
# 17	5 "	25	40
# 18	7.5 "	15	40
# 19	7.5 -	20	40
# 20	7.5 -	25	40
# 21	10	20	40
# 22	10	25	40
# 23	7.5	20	40 + 3 lbs $NaNO_3$
# 24	0	15	40 + 5 lbs [illegible]
# 25	10	20	40 3 - [illegible]
# 26	7.5	15	45 5 - [illegible]

The results are shewn on the following curve sheet.

Chart in
Envelope.
N-880610

Saturday 4th August

Electrometer (abs) gave its first measurements. At a particular distance and electricity of the idiostatic gauge, the full pressure to correspond to 0.6 gr. was produced at 0.936 = 0.468 cms on the lower screw reading. The full pressure to correspond to 0.3 gr. was produced at 0.1935 = 0.7068 cms on the lower screw. This works out

$$0.468\sqrt{\frac{8\times3.1416\times0.6\times980}{3.1416\times2.25\times2.25}} = 0.468\sqrt{\frac{78.40\times0.6}{5.0625}}$$

$$0.468\sqrt{1394\times0.6} = 0.468\sqrt{836.4} = 0.468\times28.9 = 13.5$$

$$= 405.000 \text{ volts}$$

$$0.7068\sqrt{\frac{8\times3.1416\times0.3\times980}{3.1416\times2.25\times2.25}} = 0.7068\sqrt{1394\times0.3}$$

$$= 0.7068\sqrt{418.2} = 20.5\times0.7068 = 14.49$$

$$= 434.7 \text{ volts}$$

Reweighed. Electrometer spring values as follows

0.1 gramme		0.2 gramme		0.3gr	
	0.49		0.971		1.428
	.505		0.969		1.445
	.485		0.967		1.435
Mean	0.499	Mean	0.9693	Mean	1.4327

0.5 gramme		0.4 gramme		0.6gr	
	2.3334		2.863		2.710
	2.333		1.876		2.725
	2.329		1.880		2.740
					2.735
					2.726
Mean	2.332	Mean	1.873	Mean	2.7253

Temp 80°F

Diameter of disk from several measurement 4.515

check later 0.6 gramme 2.720, 2.722, 2.729 } 2.7270

a lightning flash a mile long) requires perhaps a P.D. of 10,000,000,000 volts. If so, and if the charge is resident in individual raindrops say $\frac{1}{8}$" diam, then on the supposition that the potential of evaporated steam droplets is 1000 volts a mere estimate the diameter of those droplets should be $\frac{1}{370,000}$ of an inch.

To find the rate of accumulation of potential in cloud with coalescence.

Let there be a given mass M of water in the form of very minute droplets, electrified by evaporation. Let the number (very great) of these droplets be N, their radius r and the total charge accumulated in the mass M = Q

Then $M = 4.189\, N r^3$ $\quad (\frac{4}{3}\pi = 4.189)$ $\therefore N = \frac{M}{4.189\, r^3}$

and $q = \frac{Q}{N}$ $\quad r = \sqrt[3]{\frac{M}{N}} \times \frac{1}{\sqrt[3]{4.189}}$

$\therefore v = \frac{q}{r} = \frac{Q}{Nr}$ $\quad \frac{1}{\sqrt[3]{4.189}} = \frac{1}{1.61}$

$\therefore v = \frac{Q \times 4.189\, r^2}{Mr} = 4.189 \frac{Q}{M} r^2$

or the potential increases as the square of the radius of the drops or as their surface.

also $v = \frac{Q \times 4.189\, r^2}{4.189\, N r^3} = \frac{Q}{Nr}$

$= \frac{Q \times 1.61}{N^{\frac{1}{3}} \sqrt[3]{M}} = \frac{1.61 Q}{M^{\frac{1}{3}}} \times \frac{1}{N^{\frac{1}{3}}}$

or v increases inversely as the $\frac{1}{3}$ power of N or to ~~double v~~ halving N increases v 60%, and generally diminishing N n times increases v $n^{\frac{1}{3}}$ times.

Thus if 1,000,000 droplets coalesce the potential of the resultant drop is augmented 10,000 fold:

The density or the droplet is $\frac{M}{4Nr^3} = \frac{M}{4Nr^3}$ $\therefore$ g increases as N.

		24·7			58·8
	13·7	114·41		18·2	101·1
×	16"	153·94	×	18·5	188·67
	12·5	153·93		12·5	133·72
		31·2			66

Calculation for the effect of doubling the "entrefer" in a No 20 Edison Dynamo.

At present the diam. of the iron core of the #20 armature is given as $12\frac{1}{2}$" and the diam. of the ~~inscribing~~ boring or polar extension as 14" leaving $1\frac{1}{2}$" as ~~air space~~ entrefer or 0.75" on each side. The full armature diam is given as $13\frac{7}{8}$" leaving $\frac{5}{32}$" for mechanical clearance all round. That is a winding space of $13\frac{7}{8} - 12\frac{1}{2}$ $= 1\frac{3}{16}$" $\div 2 =$ $\frac{19}{32}$ about $\frac{2}{3}$" radially. If now the entrefer were increased to $1\frac{1}{2}$" on each side the winding space would be $\frac{48-5}{32} = \frac{43}{32}$ or the radial space would be increased from $\frac{19}{32}$" to $\frac{43}{32}$" or 125% in volume. If this were obliged by wire, at least 100% gain in output would result, for the greater thickness of wire would lessen the radiation from the lower layer and prevent the full gain of 125%. The question now remains as to the restoration of the original strength of field.

The calculation given on pages 54 + 55 of Book no 3 shew that the Hopp formula applies pretty closely. By doubling the air space the voltage of the machine would be reduced in the ratio of $\frac{1.137}{2.97}$ so that the ampere turns would have to be increased 160% but the leakage would be increased enormously the polar surface would have to be abridged to begin with; and doubling the ampere turns would perhaps redeem 80% increased output.

Plating Dynamo Continued

At a velocity of 6000 ft per min or 100 per sec. = 3050 cm. per sec. and a breadth b, the area described = 3000 b, and to obtain a voltage of v volts at a field of 3000 lines per sq cm. = $\frac{v \times 10^8}{3000 \times 10^6}$ = $\frac{100v}{3}$

= 11.2v = 4.4" per volt.

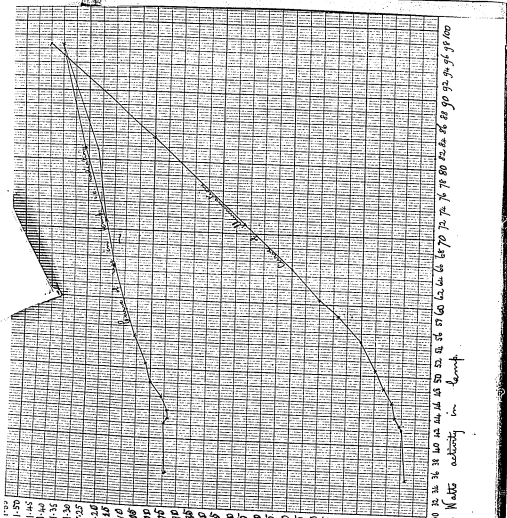
Tuesday 7th August

Completed Converter.

Took Tachograph apart and reset it again. The speed indicated by the pointer on the inside dial is about 2.03 times that of the engine flywheel.

Wednesday 8th August

Examined Westinghouse plant at Station Island. There were 3 alternating Machines (2 at work) revolving 1650 times per min with 12 Magnets radially about 10" and some 30" broad. = ~~220~~ 330 alternations per sec or 19,800 alternations per min: The indicated currents from these machines were about 47 and 57 amperes respectively at 1200 volts pressure. There were also 2 Thomson-Houston Machines one working, and 2 United States Machine 1 delivering 10 amperes at about 1900 volt pressure.



Record of Photometer test made 25th July.

(55)

Time	P.D. on side trough	P.D. on trough under test	Current thro trough under test	P.D. on resist	Temp in temp	Temp of trough outside	Watts in trough	Ratio of 1st:	B.P. of trough under test	Rise in trough F	Rise in trough C
10.38					73°F						
10.38	99.25	64.4	0.510	0.064	245°F	78°	35.2	1012.0	1.33	178°	98.5°
11.45	"	79.4	0.530	0.068	250°	83°	42.1	10.0	1.6	171°	95.0
14.55	"	79.8	0.538	0.069	254°	86°	42.9	9.0	1.778	168°	93.3
15.08	"	80.5	0.546	0.070	256°	87°	43.96	8.0	2.0	169.5	94.2
15.15	"	81.5	0.556	0.071	260	87°	46.1	7.0	2.286	173°	96.1
15.25	"	83.8	0.574	0.072	268	88°	48.1	6.0	2.667	180°	100
15.40	"	86.0	0.590	0.074	272	89°	50.7	5.0	3.20	183	101.7
15.47	"	89.0	0.614	0.077	280	90°	54.7	4.0	4.0	190	105.6
15.55	"	94.8	0.638	0.080	286	90.5	58.6	3.0	5.333	195.5	108.6
16.08	"	92.6	0.654	0.082	290	91	60.6	2.5	6.40	199	110.6
16.22	"	96.8	0.670	0.084	298	92	64.9	2.0	8.0	206	114.4
16.35	"	100.6	0.710	0.089	306	93	71.4	1.5	10.61	213	118.3
16.40	"	106.7	0.766	0.096	322	94	81.7	1.0	16.0	228	126.7
16.50	"	114.3	0.825	0.106	338	95	96.6	1.4	20.4	243	135.0

Saturday 11th August.

Required the depth of winding of 16 lbs. of # 23 BWG on the transformer core whose diam: is 6" and whose length will be 6". The diam of the wire # 23 BWG. is 0·025
Covering 0·014
0·039

The no: of turns in a layer is $\frac{6}{0{\cdot}039} = 154$.
1 lb of this wire = 528·5 ft = 6342" = 4450 ft. on 2ll.

$$l = \frac{\sqrt{36 + \frac{4 \times 6342 \times 0{\cdot}039 \times 14}{154 \times 3{\cdot}1416}} - 6}{0{\cdot}078} = \frac{\sqrt{6864} - 6}{0{\cdot}078} = \frac{2{\cdot}27}{0{\cdot}078}$$

= 29·3 say 30 @ 0·039 = 1·170"

Check on above allowing 1·27 + 6 = 7·27 as mean diam the mean circum: = 22·52" × 154 = 2472" = 290 ft nearly + 30 layers = 8700 ft.

Tried small Inductometer in Engine Room several feet from Dynamo to measure Pill.
Horizontal swing through $\frac{\pi}{2}$ Deflection on Bell gal. 56.
Vertical - - $\frac{\pi}{2}$ - - - - 28.
Throw from standard cell 0·51 - - - 123.
Diam: of wire 0·031" bare = say #14 BWG + has a res of 0·54 = 0·54 × 667·34 = 360 ft.
The external diam is 7" = 22" circum: + there are 9 turns to the layer on each reel or 18 × 22 = 396" = 33 feet so that 11 layers would be needed.

$$L_H = \frac{0{\cdot}71}{123} \times \frac{56 \times 10^{-7} \times 5{\cdot}330 \times 10^{10}}{34{\cdot}360} = \frac{7{\cdot}1 \times 5{\cdot}6 \times 5{\cdot}33 \times 10^{3}}{1{\cdot}23 \times 3{\cdot}436 \times 10^{2}} = 42{\cdot}25$$

= 21·13

L vertical

$$\sqrt{17844 + 4446} = \sqrt{2230} = 47{\cdot}2$$

Took small Grid inductor apart and examined its coils more closely to calculate its effective area. The wire is 0.083" = 0.211 cms No 14. B.W.G + its covered diam is about 0.105" = 0.267.

1) The mirror half.

Diam of channel 11.8
Diam. of fully winding 17.6 } 14.7 Mean.
Diam of 6th layer 14.9
No. of layers 11. 9 turns on top layer + 1 extra
Res. 0.265 ω @ 23°C.

If there are really 100 turns or 1500 × π cms =
$\frac{1500 \times \pi}{30.48}$ feet = 154.6 feet while the calculated length
= 0.265 × 667.3 = 176.8 feet.

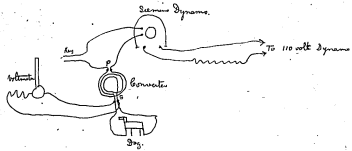
2) The back half

Diam of Channel 14.85 } 14.85 Mean
Outer Diam of winding 17.85
11 Layers 9 turns on top layer + 1 extra turn
Res 0.250 ω @ 23°C.

If there are really 100 turns or 14.85 × π cms =
$\frac{14.85 \times \pi}{30.48}$ = 153.6 feet while the calculated length
= 0.25 × 667.3 = 166.8 feet.

Res: of instrument Complete = 0.516 ω @ 75°F 23°C.

14.7 being the mean diameter of reelwinding no 1.
= 7.35 radius. = 169.72 sq. cms. × 100 = 16970 sq. cms.
14.85 being the mean diam. of reelwinding no 2
= 7.425 = 173.90 sq. cms × 100 = 17.390 sq. cms
Total area is. Plus 34360 sq. cms.



Physiological Experiment Contd.

Saturday) 11th August.

Siemens alternating Machine making 1380 revs per min = 276 alternations per sec.

Dog) ♯ 13. Black smooth terrier Weight 21½ lbs
Length 29"
Height 15"

Bandaged with wadt on opposite fore and hind legs as usual.

~~Used~~ Used large converter.

21. 13 Contact for 3 secs: in primary) Cardew voltmeter 30" = 57 × 4 = 228
− 33
195 Mean volts

Dog) quite quiet while current on and attendant did not know contact had been made, on breaking contact dog) struggled silently for a few seconds and then fell dead. The heart beat for some little time afterwards.

21. 30. Black shaggy) terrier Weight 19½ lbs
Dog ♯ 14. Length 25"
Height 14"

Used one converter. Simply the machine in ~~simple~~ circuit with dog) & voltmeter on terminal.

21. 42. Contact made for 15 secs. Cardew 70" = 98 × 2 = 196
− 20
Mean voltage 176

On breaking circuit dog) fell dead at once without any struggling. No evidence given by dog of having felt the current at all.

Dog # 15 No connector.

~~Black~~ Black beagle Weight 39 ½ lbs.
Length 26"
Height 15".

22·07 Contact made for 15 secs: Bardeen .76"
.99 × 2 = 1·98
30
178

Mean Voltage = 178

Dog gave no sign during application of current, standing rigidly like mus 13 + 14 without spasms or trembling + fell slowly on breaking circuit without uttering any sound. One or two disconnected gasps were heard, but the eyes were glassy and unresponsive, and dog evidently unconscious. Lung action quite ceased within 60 seconds.

Checked Bardeen voltmeter by lamps and also by direct current machine.

The field strength as indicated by the Grd Inductor is as follows—

Let θ be the throw from the standard cell thro 0.5 f

Then $Q = 0.5 \times 1.43 = 0.715 \times 10^{-8}$

The res: of the circuit is about 5340×10^{3}

Let the throw observed be t

Then $\frac{t \times 5.34 \times 10^{12}}{\theta} \times 7.15 \times 10^{-8}$ = Total Lines cut

or $\frac{t}{\theta}\left(\frac{5.34 \times 7.15 \times 10^{4}}{34.360 \times 10^{6}}\right) = \frac{t}{\theta}(1141)$

Chart in Envelope

Grenet Battery Trials.

The same solutions as those experimented with on the 2nd August were tried again on the 10th August, but with zinc having 10% Mercury in alloy instead of 5%.

The order of failure was (below 2 ampères)

# 22	at ½ hour	
# 15	-	9% -
# 16	-	-
# 17	-	-
# 25	-	-
# 26	-	-
# 18	-	11% -
# 19	-	11% -

leaving #s 20 and 21 still active after 12 hours

at	#20	1.950 volts	2.738 ampères
	#21	2.064 -	2.260 -

The zinc lost was as follows.

#	grammes	The previous results were grammes
15	91.8	86.5
16	85.7	83.3
17	61.8	73.2
18	121.	105.6
19	98.5	99.0
20	104.2	112
21	128.0	130
22	104	~~69.7~~ 119
25	64.9	69.7
26	77.7	101.7

Monday 13th August.

After rating watches, took them into E.R. where they have been running for 48 hours, and measured the field at a position about 130 cms. from the pole-piece on the western side of #20 machine, that is to say near its north pole.

The throws from the Erdinductor were 186, 187, 18 17

The standard coil throw 126

The Resolved throw is thus about 187.5 and the field $= 111.1 \times \frac{187.5}{126} = 165.5$ C.G.S.U. $\frac{2}{2}$ = 83

The watches were exposed to this field from 9.18 to 9.33 (15 mins). They were then placed out of magnetic range in the E.R.

Wednesday 15th August.

After rating watches, took them again into E.R. and measured the field at a position close to the N. pole of the #20 machine (on the street side of it). The throws were

horizontally 226 } Resolved = 237
vertically 65

Throw thus 0.5" 126

$$\mathcal{H} = \frac{237}{126} \times \frac{1.03 \times 10^{10} \times 7.15 \times 10^{-8}}{3.4326 \times 10^{10}} = \frac{237}{126} \times 2.14 \times 3 = \frac{1403}{2} = 200 \text{ C.G.S.}$$

Plating Dynamo. EMF 5.81 volts
P.D. at baths 2.893

Res. of baths 0.08 ω (3 in series) = 0.017 ω
Res. of leads to baths (circuit) 1.82 ω.
Res. of dynamo + leads 0.05 ω

Chart in Envelope N-880610

Copy of Mr Marshall's Lamp Data

No	Wpl	C.P.	Watts	No	Wpl	C.P.	Watts	No	Wpl	C.P.	Watts
1	7.46	7.496	55.93	29	5.83	10.644	62.27	57	4.78	14.310	68.40
2	7.39	7.602	56.19	30	5.71	10.805	62.46	58	4.75	14.448	68.63
3	7.31	7.709	56.36	31	5.74	10.928	62.73	59	4.72	14.586	68.83
4	7.24	7.816	56.59	32	5.69	11.051	62.86	60	4.69	14.725	69.06
5	7.17	7.925	56.83	33	5.65	11.175	63.16	61	4.66	14.864	69.29
6	7.10	8.033	57.04	34	5.61	11.299	63.38	62	4.63	15.004	69.47
7	7.04	8.142	57.32	35	5.57	11.424	63.65	63	4.61	15.144	69.81
8	6.97	8.253	57.52	36	5.53	11.549	63.87	64	4.58	15.285	70.01
9	6.91	8.362	57.79	37	5.48	11.675	63.97	65	4.55	15.430	70.23
10	6.84	8.473	57.97	38	5.44	11.801	64.18	66	4.53	15.57	70.53
11	6.78	8.584	58.21	39	5.41	11.928	64.55	67	4.50	15.71	70.69
12	6.72	8.696	58.44	40	5.37	12.055	64.73	68	4.47	15.86	70.89
13	6.66	8.808	58.66	41	5.33	12.184	64.91	69	4.44	16.00	71.09
14	6.60	8.921	58.88	42	5.29	12.313	65.12	70	4.42	16.14	71.34
15	6.54	9.034	59.10	43	5.25	12.442	65.32	71	4.39	16.29	71.61
16	6.49	9.149	59.38	44	5.22	12.572	65.60	72	4.37	16.43	71.80
17	6.43	9.263	59.57	45	5.18	12.702	65.78	73	4.34	16.60	72.04
18	6.38	9.379	59.84	46	5.14	12.833	65.93	74	4.32	16.73	72.27
19	6.32	9.495	60.02	47	5.11	12.964	66.24	75	4.29	16.87	72.37
20	6.27	9.611	60.26	48	5.07	13.096	66.40	76	4.27	17.02	72.68
21	6.22	9.728	60.52	49	5.04	13.229	66.67	77	4.24	17.17	72.80
22	6.16	9.845	60.66	50	5.01	13.362	66.94	78	4.22	17.32	73.09
23	6.11	9.963	60.89	51	4.97	13.496	67.08	79	4.19	17.47	73.26
24	6.06	10.082	61.09	52	4.94	13.630	67.33	80	4.17	17.62	73.48
25	6.01	10.201	61.29	53	4.91	13.765	67.59	81	4.14	17.78	73.64
26	5.97	10.321	61.60	54	4.88	13.901	67.84	82	4.12	17.93	73.83
27	5.92	10.441	61.91	55	4.84	14.036	67.93	83	4.10	18.07	74.08
28	5.87	10.562	61.98	56	4.81	14.173	68.17	84	4.08	18.22	74.37

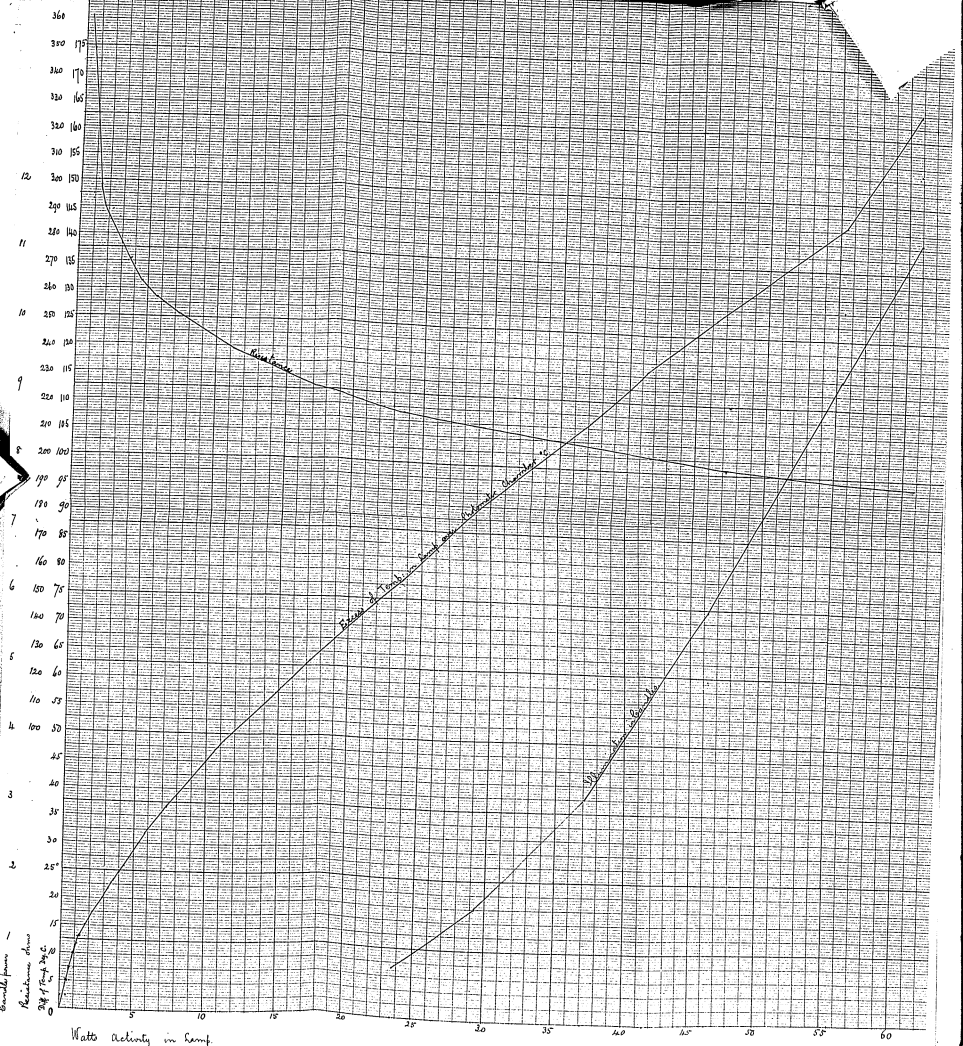
	W.p.c	B.P	Watts	No	W.p.c	B.P.	Watts	No	W.p.c	B.P.	Watts
95	4.06	18.38	74.62	115	3.49	23.22	81.03	145	3.06	25.57	87.42
96	4.04	18.53	74.86	116	3.47	23.39	81.16	146	3.04	25.75	87.40
97	4.01	18.68	74.91	117	3.45	23.56	81.28	147	3.03	25.94	87.69
98	3.99	18.84	75.17	118	3.44	23.73	81.62	148	3.02	29.13	87.97
99	3.97	18.99	75.39	119	3.42	23.90	81.73	149	3.01	29.32	88.25
100	3.95	19.15	75.66	120	3.41	24.08	82.10	150	3.00	29.51	88.53
101	3.93	19.30	75.86	121	3.39	24.25	82.20	151	2.98	29.70	88.51
102	3.91	19.46	76.09	122	3.38	24.42	82.54	152	2.97	29.89	88.77
103	3.89	19.62	76.32	123	3.36	24.60	82.65	153	2.96	30.08	89.04
104	3.87	19.78	76.55	124	3.35	24.77	82.98	154	2.95	30.27	89.30
105	3.85	19.93	76.73	125	3.33	24.95	83.08	155	2.94	30.46	89.55
106	3.83	20.09	76.95	126	3.32	25.12	83.40	156	2.93	30.65	89.80
107	3.81	20.25	77.16	127	3.30	25.30	83.49	157	2.92	30.85	90.08
108	3.79	20.41	77.35	128	3.29	25.47	83.80	158	2.91	31.04	90.33
109	3.77	20.57	77.55	129	3.27	25.65	83.88	159	2.89	31.23	90.25
110	3.75	20.73	77.74	130	3.26	25.83	84.20	160	2.88	31.43	90.32
111	3.73	20.90	77.95	131	3.24	26.01	84.27	161	2.87	31.62	90.75
112	3.71	21.06	78.12	132	3.23	26.19	84.59	162	2.86	31.82	91.01
113	3.69	21.22	78.29	133	3.21	26.37	84.64	163	2.85	32.02	91.26
114	3.68	21.38	78.68	134	3.20	26.55	84.96	164	2.84	32.21	91.48
115	3.66	21.55	78.87	135	3.18	26.73	84.99	165	2.83	32.41	91.72
116	3.64	21.71	79.02	136	3.17	26.91	85.30	166	2.82	32.61	91.96
117	3.62	21.88	79.20	137	3.16	27.09	85.60	167	2.80	32.81	91.87
118	3.60	22.04	79.34	138	3.15	27.27	85.90	168	2.79	33.01	92.10
119	3.59	22.21	79.73	139	3.13	27.46	85.94	169	2.78	33.21	92.32
120	3.57	22.38	79.89	140	3.12	27.64	86.23	170	2.77	33.41	92.54
121	3.55	22.54	80.02	141	3.11	27.82	86.51	171	2.76	33.61	92.76
122	3.53	22.71	80.17	142	3.10	28.01	86.83	172	2.75	33.81	92.97
123	3.52	22.88	80.53	143	3.08	28.19	86.83	173	2.74	34.01	93.18
124	3.50	23.05	80.67	144	3.07	28.38	87.15	174	2.73	34.21	93.39

Physiological Experiments contd.

Dog #16
Black + White Collley
Length 35"
Height 21"
Weight 57½ lbs.

21.27 After securing in box. Respiration 142 per min.
Direct Current from Municipal Machine
in direct set with dog. Voltage 400.
21.30 Contact made for 40 seconds.
Dog howled once on application of current,
consciousness ceased apparently after 15 sec.
judging by the eye. The breathing
became stertorous in a few gasps.
On breathing contact No sign of life.
Through an oversight the ammeter not read

No.	W. per B.	C. P.	Watts		No.	W. per B.	C. P.	Watts
175	2.72	34.42	93.62		191	2.45	40.99	100.43
176	2.71	34.62	93.82		192	2.40	42.33	101.59
177	2.70	34.83	94.04		193	2.35	43.91	103.19
178	2.69	35.03	94.23		194	2.30	45.30	104.19
179	2.68	35.24	94.44		195	2.25	47.16	106.31
180	2.67	35.44	94.61		196	2.20	48.82	107.40
181	2.66	35.65	94.82		197	2.15	50.76	109.13
182	2.65	35.86	95.03		198	2.10	52.73	110.73
183	2.64	36.06	95.20		199	2.05	54.99	112.73
184	2.63	36.27	95.39		200	2.00	57.00	114.00
185	2.62	36.48	95.58		201	1.95	59.92	116.84
186	2.62	36.69	96.12		202	1.90	62.57	118.92
187	2.61	36.90	96.31		203	1.85	65.60	121.36
188	2.60	37.11	96.49		204	1.80	68.39	123.10
189	2.55	38.38	97.87		205	1.75	72.80	126.18
190	2.50	39.68	99.20		206	1.70	75.61	128.52
					207	1.65	79.80	131.67
					208	1.60	84.00	134.40
					209	1.55	88.85	137.72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Watts activity in Comp.

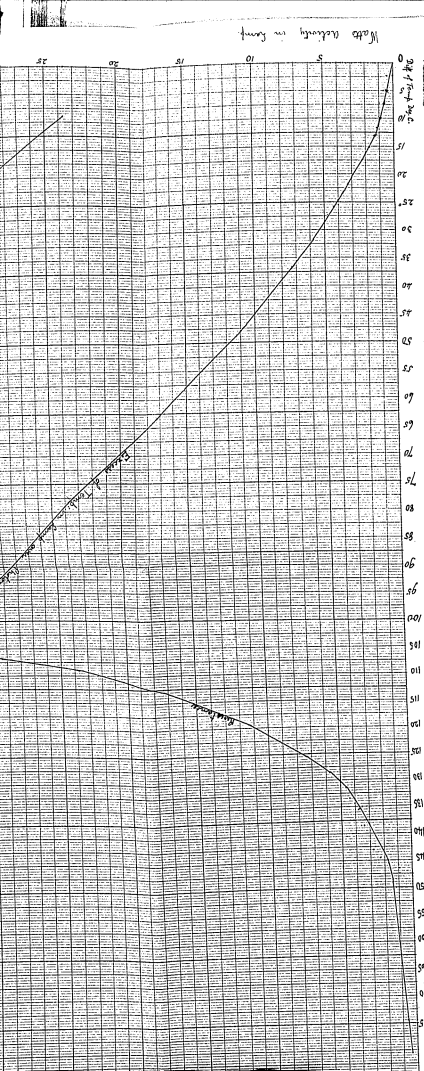
Particulars of a Tantalum Lamp. No. III. August 88

A new 16 cp lamp was fixed with the same harmometer as that used in the first trial see Books II and III, and exhausted. The vacuum was pronounced good, but the lamp failed under trial next day evidently owing to an imperfect vacuum at that time.

The standard against which its illumination was compared was a lamp given us by Mr Marshall as a Newark standard 16 cp at 101 volts. It was maintained at c.p. by the S.B. voltmeter.

Two selenium cells were placed in the photometer to ascertain if their conductivity increased with the illumination. The figures show that it did not do so to any decided extent.

The current passing through the lamp was measured by sending it also through the legal ohm whose electrodes stood in mercury cups, and measuring the P.D. between these cups by potentiometer. The P.D. on the lamp was measured by potentiometer with a reducer in the form of a bridge 100 : 9900. The Resistance of the lamp was calculated as $\frac{E}{C}$ and the activity in the lamp by E.C.



A new 16 c.p. lamp was fixed with the same thermometer as that used in the past trials see Books II and III, and exhausted. The vacuum was pronounced good, but the lamp failed under trial next day) evidently owing to an imperfect vacuum at that time.

The standard against which its illumination was compared was a lamp given us by Mr Marshall as a Newark standard 16 c.p. at 101 volts. It was maintained at c.p. by the S.B. voltmeter.

Two selenium cells were placed in the photometer to ascertain if their conductivity increased with the illumination. The figures show that it did not do so to any decided extent.

The current passing through the lamp was measured by sending it also through the legal ohm whose electrodes stood in mercury cups, and measuring the P.D. between those cups by potentiometer. The P.D. on the lamp was measured by potentiometer with a reducer in the form of a bridge 100 : 99.05.

The resistance of the lamp was calculated as $\frac{E}{C}$ and the activity in the lamp by E.C.

Time	Res. in ohms	Current in lamp	P.D. on lamp T.	Actinic Watts in lamp	Res. of lamp	Candle Power	# Reg.	Internal Temp. °C	External Temp. °C	Diff. of temp. °C	Res. of col. cell #1	Res. of col. cell #2	Degree of Illumination	
13.20	2.960	0.036	13.0	0.47	361	—	1	24.4	22.2	2.2				
·30	2.460	0.042	15.34	0.68	349	—	2	27.7	22.7	5.0	4750	387	nil.	
·40	1.960	0.058	17.0	0.99	293	—	3	30.0	22.7	7.3	do.	do.	—	
·50	1.910	0.058	17.2	0.99	297	—	4	32.2	22.7	9.5	do	do	—	
·55	1.760	0.062	18.6	1.15	300	—	5	33.3	22.7	10.6	-	-	Faint glow just visible	
14.05	1.660	0.066	19.6	1.29	297	—	6	34.4	22.7	11.7	-	-		
·15	1.460	0.077	22.4	1.73	291	—	7	35.7	22.7	13.0	-	-	dull red	
·25	1.310	0.096	24.8	2.13	289	—	8	37.7	22.7	15.0	-	-		
·35	1.160	0.100	28.6	2.86	286	—	9	40.0	22.7	17.3	-	-		
·45	1.110	0.110	30.0	3.30	277	—	10	42.7	22.7	20.0	-	-	-	
·55	1.080	0.114	30.8	3.51	270	—	11	44.4	22.7	21.7	-	-	-	
15.05	·920	0.116	31.4	3.64	271	—	12	45.5	22.7	22.8	4734	384	-	
·15	·850	0.122	32.8	4.0	269	—	13	46.1	23.0	23.1	4725	-	-	
·25	·795	0.128	34.2	4.38	267	—	14	47.7	23.	24.7	-	-		
·35	·750	0.134	35.2	4.72	263	—	15	48.8	23	25.8	-	-		
·45	·610	0.150	38.6	5.79	257	—	16	51.1	23.3	27.8	-	-		
·55	·460	0.170	42.6	7.24	251	—	17	55.0	23.3	31.7	4710	383		
16.05	4.10	0.216	51.6	11.15	239	—	18	60.0	23.3	36.7	-	-	bright red.	
·15	2.85	0.276	62.4	17.22	226	—	19	72.2	23.5	48.7	-	-		
·25	2.30	0.330	71.8	23.70	218	0.73	20	87.2	23.8	63.4	-	-		
·35	1.85	0.370	79.2	29.3	214	1.6	21	102.4	24.1	78.3	4698	..	glowing	
·45	1.00	0.424	87.4	37.05	206	3.2	22	116.6	24.4	92.2	4694	-		
·55	.86	0.450	92.2	41.5	205	4.57	23	133.3	25.0	108.3	-			
17.05	.71	0.480	96.6	46.37	201	5.93	24	143.3	25.0	118.3	-			
·15	.52	0.530	105.0	55.65	198	9.41	25	153.3	25.3	128.0	-			
·25	.42	0.556	109.6	60.92	197	11.43	26	171.1	25.5	145.6	-			
·35		0.606	120.	at this point		Candle		193.3	26.1	167.2	4705			
·45		lamp broke with pointed end, and				power suddenly fell. was soon afterwards the								
						every appearance of failure in vacuum.								

Thursday 16th August.

The weight of 1000 cm. of oxydized iron wire is on the average from 3 April 114.814 gms. The mean diam. of the wire being .0198"

∴ The winding wire is 254.47 = 176.71 sq in.
= 77.76 sq in.
= 388.8 c.in.

$.0198^2 = (1.98 \times 10^{-2})^2 = 3.92 \times 10^{-4}$

∴ the length of wire is $\frac{388.8}{3.92 \times 10^{-4}} = 99.2 \times 10^4$ "

$= 8.275 \times 10^4 = 82,750$ feet $= 252.1 \times 10^4$ cm.

$= \frac{2521 \times 114.84}{453.6} = 82.40$ lbs.

Measured the diameter of certain wire for heating.

1	Platinum	0.0041"	15	Steel	0.0152"
3	Gold	0.0172"	17	Brass	0.0158"
5		0.0152"	19	Iron	0.0172"
7	Aluminium	0.0152"	21	German Silver	0.0172
9	Magnesium	0.0172"	23	Solder	0.0420"
11	Cadmium	0.0208"	25	Copper	0.0152"
13	Tin	0.0172"	27	Lead	0.0240"
			29	Nickel	0.0126"

Magnifying power of 4" equatorial by ~~estimation~~
20.8.98 from lunar observations
50 diameters.
Small star finder 12 diameters.

Thursday) 17th August.

Measured the field of the #20 Dynamo in the space between the pole cores close above the brass grating. A frame of insulated copper wire about 10·25 × 36·8 cm embracing surface 377 sq. cms. was rotated through it. The observed throw was 14·0·5 that from 7.15×10^{-5} through the galv. 120.

$$b = \frac{14 \cdot 0 \cdot 5}{120}\left(\frac{5 \cdot 324 \times 7 \cdot 15 \times 10^{-5}}{3 \cdot 77 \times 10^{2}}\right) = 10 \cdot 13 \times 10^{-4} \times 1 \cdot 17$$

$$= \frac{1 \cdot 185}{2} \times 10^{-4} = 590 \text{ CGS U.}$$

Physiological Experiments. cont.

Yellow Mongrel — Weight 18½ lbs.
Length 24 inches
Height 14

Bandage on opposite corner leg as usual. Arranged to connect in direct circuit with 3 wire system mains. Could not detect respirations by sight.

21.17 Current on (220 volts.) barely

$47 = 72 \cdot 5 \times 3 = 217 \cdot 5$ volts. Contact maintained for 60 second. Amperes 0·2 steady. Dog howled + struggled violently in great pain. On breaking circuit not much hurt apparently. Could stand and walk.

21.33 Arranged alternating current machine volts $78 \times 2 = 156 - 15 \cdot 6 = 140 \cdot 4$ volts (mean) Current applied steadily for 15 secs. The dog never howled even on applying current. Unconsciousness ensued in 30 seconds and dog was quite dead when current removed. Should wait 1½ hrs.

Friday 18th August.

Mr Ward brought an assortment of watch hair springs which he tested before us as follows.

5 Hair springs were selected for heating in Trial Number 1.

These were

(1) Waltham. steel 0.0083 × 0.0032.
(2) Dufaux & Lutz steel best quality 0.0092 × 0.0032
(3) Howard steel
(4) Paillard palladium 0.0082 × 0.0032
(5) Elgin steel (with brass collett) 0.0102 × 0.0029

These were arranged on the end of an iron spatula as shown, and the spatula was then heated by a spirit lamp flame from beneath, at 16.02

at 16.03 The waltham spring was seen to distend and was removed while the palladium spring took its place. At 16.04½ a slight distension was observed in the Howard spring which was then removed and the springs were then as follows

At 16.09 a slight deformation in the plane of the Elgin was observed.

16.11 Heated edge of spring to redness. Slight deformation of outer coil in each case.

The springs were now cooled and examined.

(1) The best was the Paillard palladium which was very slightly deformed on outside turn but all other coils and planes perfect.

(2) Dufaux Lutz. Next best. Plane perfect but slight deformation in spacing at edge.

(3) Howard } both slightly deformed in plane + spire.
(4) Elgin }

(5) Waltham badly deformed in spire and slightly in plane at edge.

2nd trial. These same springs were tested for elasticity after heat.
The distension was 16 cms linearly between ends of spring held in forceps

(1) Dufaux-Lutz, distortion on two outer spires to extent of 0·3 cms

(2) Palladium, general distortion 0·4 cms.

(3) Elgin
(4) Waltham } equally distorted about 2·5 cms.
(5) Howard

3rd trial. Simple distension without heating.
The spring tried were:

(1) Dufaux-Lutz best quality
(2) Dufaux Lutz 2nd do
(3) Waltham
(4) Elgin
(5) Howard
(6) Palladium
(7) Common swiss 0·009" × 0·0025"
(8) Common swiss better quality 0·009" × 0·0022"

16 cms linear extension.

(1) Dufaux-Lutz 2nd quality came out but one trial, no visible distortion
0·009" def × 0·0032"

(2) } Dufaux-Lutz 1st Quality one trial
(3) } and Pallard Palladium 7 trials came out equally well.
Slight distortion of Duf. L.

Pallard (1) Slight distortion on outside spire
(2) - - - -
0·0084" (3) - - - two do do.
(4) - - - barely noticeable outside do
(5) - - - - -
(6) No visible distortion
(7) Slight distortion barely noticeable do L.

(4) } Howard on single trial and
(5) } Elgin on four trials came out about equal

Howard distorted (by dishing)		0·3 cms.
Elgin #1		0·6 "
Elgin #2	None visible	0·0 "
Elgin #3		0·5 "
Elgin #4	None visible	0·0 "

(6) Waltham on single trial distorted 0·7 cms dishing on 5 or 6 outside spire

(7) 2nd quality (better) of Common ~~stel~~ swiss spring

#1.	distorted (by dishing)	1·2 cms
#2	" " "	2·5

(8) 1st quality common of common steel swiss spring
~~Best~~ trial distorted (by dishing) 3·6 cms
2nd " " " " 0·5 "

Heat Test 4th trial.

A Bunsen Burner was first tried as the source of heat but autosegnually as this was too slow, a blowpipe & bellows were substituted which brought springs on copper spatulas to redness in a few seconds.

(1) The best was the Elgin very slight distortion
(2) Next was the Howard
(3) Pollard
(4) } Waltham } about equal distortion.
(5) } Ruty }

The other springs tried broke before fair comparison made.

Sunday 19th August

Ascended hill with 2 aneroids to ascertain height of summit

height of summit		(1) Kew	(2) Barnetts	Difference (1-2)	Elevation (1-2)	Dip	Ref.
14·15	Left residence	30·024	29·61	0	0		
·37	Reached Summit	29·605	29·12	375	460		
15·25	Left Summit	29·600	28·96	380	410		
·29	Below Cliff.	29·680	29·00	310	400		
·15	Level of Queen's Hotel	29·824	29·300	105	105		
·58	Queen Laboratory	30·033	29·41	0	0.		

The weight of the indications of (1) are say 3 times as great as that of (2) so that mean elevation of summit = $\frac{1140 + 410}{4} = \frac{1550}{4} = 390$ feet.

Point reached bore just N.W. of St Johns R.C. Church spire or N. 76° W. Map from Laboratory < between Lady (Abbey Green) + St Johns Spire being 31°. 10'

Monday 20th August

11.28 Exposed watches 3 at a time to strong magnetic field between the poles of pendulum el. magnet. Current about 5 amperes. Measured field by means of a small spool of wire, whose constants are as follows.

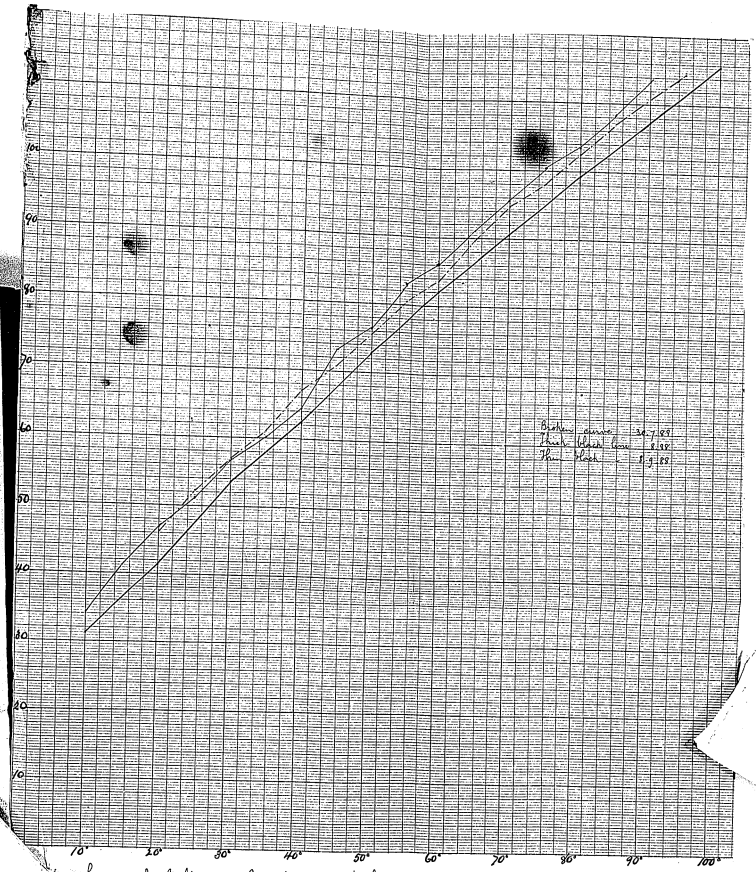
The wire diam 0.2575"
- outer - 0.5075"
- breadth 0.5

This was wound with 7 layers of silk covered wire. The 1st layer had 16 turns the 2nd 15 and all the other outer layers had 14.

The calculated total area enclosed was 78.9 sq. cms.

The throw produced by rotating this through $\frac{\pi}{2}$ was 63 divs. twice successively and the throw from the standard cell was 121 so that $h = \frac{63}{121}\left(\frac{5.316 \times 7.15 \times 10^{8}}{78.9}\right) = \frac{25\,10}{2} \text{ C.G.S.U.} = 1260 \text{ CGSU}$

All the watches stopped during the exposure to this field. They were unexposed & lay dial up.

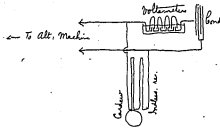


Curve of Voltmeter Readings 21st August 1888.

Tuesday, 21st August

[illegible] it in the alternating current.
[illegible]ed it in charging a small condenser
[illegible] the view of ascertaining whether any
[illegible] effect could be observed.
The mean EMF was about 110, the alternati[illegible]
[illegible] per sec: No heating effect could
[illegible] observed during half an hour, but
[illegible] experiment was made, and a
[illegible] amount of heat might have been
[illegible] without noticing it.
A larger condenser of nearly 3 [illegible] capy.
was then employed, and after removing
[illegible] at one time from the circuit, a
discharge was observed to take place on
[illegible] the terminal.
A flat irregular cake of resinous material
had 10 pairs holes pierced in it as shown
in plan. Couple 1 took the
main electrode. The other couple
took loops of different sized platinum
wire. The sizes were 0.0015" pt.
0.004" pt
0.0075 pt. iridium
0.008 pt

The free ends of the loops were connected
beneath and then all the wires beneath
were sealed up by pouring hot sealing
wax on them. Finally the loops
standing above were cut about 2 cms from



the brass thin leaving four little voltameter of plates formed by upright wire. The whole was submerged in dilute H_2SO_4 in an evaporating dish, and connected in to the Condenser circuit.

Only two of the voltameter gave any discharge. Although bubbles of gas could be detected on the surface of the other wires. The finest wire gave a splendid discharge. The next size 0.004 about half as much. The gas developed by the finest wire voltameter was observed to be 7.6 c.c. in 14 m. 0 sec. or 840 sec. the Bar. being about 29.7" and the temp 70° F. The EME during that time was observed to be $78.4 \times 2 = 156.8 \times 0.9 = 141.2$ = mean voltage

$\frac{141 \times \pi}{2} = 70.5 \times \pi = 221.5$

In 840 sec. the quantity of electricity entering the condenser would be

$2 \times 840 \times 2.94 \times 2.75 \times 10^{-7} \times 221.5$

$= 2 \times 8.4 \times 2.94 \times 2.75 \times 2.215 \times 10^{-1} = .3021$ ac.

Each C deposes 0.0001038 gm. H.

∴ the qty H. produced should be $3.021 \times 10^{-1} \times 1.038 \times 10^{-4}$
$= 3.124 \times 10^{-5} = 0.00031$ gm.

a gramme equiv 11000 c.c. so that the H developed would be $1.1 \times 10^{4} \times 3.1 \times 10^{-5} = .341$ c.c. and the mixed gas would be 68.2 c.c.

Gardner voltameter Comparison by Potentiometer.

	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
Volts	34.4	41.8	53.9	62.8	73.0	82.2	90.66	99.59	107.91	115.83

Wednesday 22nd. August.

Exposed watches at 11.0 to a very severe field. Current through large magnet about 10. amperes. (24 ohm ring 52.30) and the J.P.D. 2.1 One watch was placed in this field at a time vertically, #s 6 and 9 stopped altogether after this ordeal. The Condenser throw was 116 the throw from the field explorer 70 (mm) so that the field is

$$\frac{7.0}{116}\left(\frac{5.94 \times 7.15 \times 10^{3}}{7.9}\right) = \frac{7.0}{116}\left(4.834 \times 10^{3}\right) = 292 \times 10^{3}$$

$= 2920$ C.G.S. U.

Repeated Electrolytic alternating Experiments. Prepared two voltameters of platinum wire plates 0.001 and 0.002" diam. respectively. Length of each wire about 2 cm. Placed these in two separate evaporating dishes and placed them in series with the condenser used yesterday and whose capacity we checked as 2.957 ∎. It is marked 2.58 ∎. The gas liberated in a certain time not noted was found to be apparently equal (certainly within 5%) from both voltameters. On cutting the wire down so as to lessen the exposure, disruptive explosions accompanied by sparks occurred on making and also on breaking the condenser circuit. These ended in breaking of the plates. The indicated voltage was 8.5 volts mean.

20th August 1888

#17 Brown terrier Weight 20 lbs
Length 26"
Height 14"
Res: 8000ω
Respiration 144 per min.

Used direct continuous current
20.45 Contact 35 secs: Volts 75" × 3 =
95" × 3 = 285 – 285 × 25% Amperes 0.035.
Dog howled when current applied
set head down results could not be
seen. When current removed dog dead.
Res: after death little under 1000ω

#18 Black and tan terrier Weight 16½ lbs.
Length 27"
Height 13½"
Res. 4200ω

Dog breathing quietly Res: unable to note
21.23 Alternating current ruly 300 per
sec: Contact 2 secs.
Volts. 100" × 4 = 116 × 4 = 464 – 46 = 418 volts
Dog howled slightly on applying current
On removal of current death not
instantaneous but followed silently in
about 30 secs. Res: after death 4700ω.

Thursday 23rd August

Ran a new phono. motor @ follows.
New Grenet cell 5% Hg-Zn alloy)

Commenced trial at 17.0

Condition	Revs per min	E.	Volts	Watts
Running light	106	2.84	1.802	5.12
Spectacle down	100	2.84	1.742	4.95
Running off ½"	96	2.84	1.717	4.87
Running off 1"	92	2.84	1.607	4.56
Machine held	0	2.84	1.549	4.40.
Grenet altered				
Running light	80	2.84	1.738	4.94
Spectacle down	80	2.84	1.730	4.91
Running off 1"	80	2.84	1.719	4.88

Set machine running on a new cell, at 18.0
E. 2.84 V. 1.799.

21 o'clock E. 1.63. 1.716

The instrument was removed for one hour at 21.45 but with that exception continued running all night. Speed falling slowly. Instrument continued to run till 14.30 the last speed being 36 revs. E. 1.44.

Friday 24th August.

16.38 Set 9 meter bottle to work as follows:

		Weight	Sum
1	25.0048	48.1772	48.1756
2	23.1708		
3	25.1419	48.4910	48.4899
4	23.3480		
5	24.2415	49.0244	49.0233
6	24.7818		
7	25.0218	49.5428	49.5424
8	24.5006		
9	24.6624	49.2587	49.2574
10	24.5950		
11	24.1605	48.9504	48.9488
12	24.7080		
13	25.0602	50.1629	50.1622
14	25.1028		
15	24.1752	48.8266	48.8244
16	24.6492		
17	24.1430	47.8698	47.8688
18	23.7258		
19	24.0566	47.8118	47.8102
20	23.7536		

These plates with the exception of #20 were 1% Mercury alloy plates of pure zinc prepared by Wilmoski. The solution was that used last time. #20 was an ordinary zinc plate unamalgamated. #19 + #20 were joined up in circuit for 75 min with 2 ampères but not intended for work + thrown out.

Exposed watches right through their ~~the~~ hair spring to a powerful field produced by pointed polepieces at 2 cms. in. p. dist. The throw from 0·54 being 118. that from the field explorer for $\frac{\pi}{2}$ was 193 with 55° (abt 10 amps) on ring tangent. The field was thus

$$\frac{1}{2}\,\frac{193}{118}\,(4\cdot834\times10^{3}) = 3950 \text{ C.G.S.U.}$$

Saturday 25th August.

Exposed Watch #1 to a condensed powerful field maintained by about 7 amperes with the pointed poles at about 1·6 cms int. p. dist. The single throw with the field explorer was 111 that from the condenser 120·5 so that the field was. $\frac{111}{1205}(4\cdot834\times10^{3}) = 4450$ C.G.S.U. This was directed as closely as possible upon the centre of the balance wheel.

The ~~error~~ of the watch by the clock was compared by means of the chronograph and a contact breaking key from time to time but it was found that the indications thus obtained were irregular and useless owing it was supposed to the shifting of the minute hand under the attraction which visibly took place between it and the poles. Consequently a run of 11 minutes was taken and the rate during this period was carefully

compared by chronograph. It is appended and shews a gaining rate of 1·376 secs. per min.. Starting with this basis the previous observations were worked up correcting for the hand shifting as follows

No.	Clock Time	Indicated Watch Time	Corrected Watch Time (Mean Sol. Time)	Differences	Rate	Gain in that interval	Rate from interval	
1	12·00·00	12·00·11·5		+11·5				
					72			
2	11·46·7·8	11·46·00		−7·8	+1·388	19·3	+1·388	
3	11·33·26·2	11·34·00	11·33·00	−26·2	+1·392	16·14	+1·291	
					48	16·8		
4	11·20·41	11·21·00	11·20·00	−41	+1·336		+1·323	
					48			
5	10·43·33	10·38·00	10·42·00	−93	+1·367	52	+1·398	
					227			
6	9·34·127	9·32·00	9·31·00	−127	+1·401	99·7 ~~397~~	+1·438	

compared by chronograph. It is appended and shews a gaining rate of 1·376 secs per min.. Starting with this basis the previous observations were worked up correcting for the hand shifting & pillars

No.	Clock Time	Indicated Watch Time	Corrected Watch Time taking 1st Obs.	Difference	Rate	Gain in last interval	Rate during interval
1	12·00·00	12·00·11·5		+11·5			
2	11·46·78	11·46·00		−7·8	+1·388	19·3	+1·388
3	11·32·00	11·31·00	11·33·00	−21·2	+1·342	16·4	+1·291
					+1·336	16·8	+1·323
					+1·367	52.	+1·398
					+1·401	99·7	+1·438

To find the rectilinear equation of motion of a particle attracted to a centre with a force directly as the distance and retarded with a force directly as the velocity.

$r = ce^{-\rho \cot a}$ where c is a constant
r . the radius vector
a . . angle of the spiral
ρ . . . described from O.

Let $\rho = \omega t$

$x = a + r \sin\rho$

Then $x = a + c \sin\omega t \, e^{-\omega t \cot a}$

$$\frac{dx}{dt} = c\omega \cos\omega t \, e^{-\omega t \cot a} + c \sin\omega t \, e^{-\omega t \cot a}(-\omega \cot a)$$

$$= c\omega e^{-\omega t \cot a}(\cos\omega t - \sin\omega t \cot a)$$

$$\frac{d^2x}{dt^2} = c\omega e^{-\omega t \cot a}\{-\omega \cot a(\cos\omega t - \sin\omega t \cot a) - \sin\omega t(\omega) - \cos\omega t \cot a\,\omega\}$$

$$= c\omega^2 e^{-\omega t \cot a}\{-2\cot a \cos\omega t + \sin\omega t \cot^2 a - \sin\omega t\}$$

$$= c\omega^2 e^{-\omega t \cot a}\{\cot a(\cos\omega t - \sin\omega t \cot a) - \sin\omega t(\cot^2 a - 1)\}$$

$$= -2\omega \cot a \frac{dx}{dt} - \omega^2(x-a)(\cot^2 a - 1)$$

$$= -2k\frac{dx}{dt} - \frac{\omega^2}{\sin^2 a}(x-a)$$

$$= -2k\frac{dx}{dt} - \mu(x-a)$$

$$\frac{d^2x}{dt^2} + 2k\frac{dx}{dt} + \mu(x-a) = 0$$

where $2k$ is $2\omega \cot a$ = the component of retardation
and μ $\frac{\omega^2}{\sin^2 a}$ = - - - attraction.

vide C. Maxwell page 346 Vol 2 where a different solution is given.
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Let m' be the mass of an imaginary projectile the projection of whose trajectory on the scale shall coincide with the actual movement of the spot and whose energy shall at all times be equal to the energy of the needle.

Then if ω be the ang. vel. of needle at centre of scale and of the projectile at the outset $\frac{1}{2} m r^2 \omega^2$ ~~the~~ $= \frac{1}{2} I \omega^2$. where r is the radius ~~of~~ of the projectile and I is the moment of inertia of the needle. Then $m r^2 = n r_1^2$.

or $\frac{r}{r_1} = \frac{\sqrt{n}}{\sqrt{m}}$ where n is the mass of the needle and r_1 its radius of gyration about its central stem. and $m = \frac{n r_1^2}{r^2}$

Here r is always determined by the initial impl.

Let the initial energy of the projectile be $\frac{m v^2}{2}$. Then $v = \rho \omega_1$ where ω is the ∠vel that the projectile would have if its orbit were circular but $\not\propto \omega_1 = \frac{\omega}{\sin a}$

$$\therefore v = \frac{\rho \omega}{\sin a}$$

$$\text{and } \frac{m v^2}{2} = \frac{m \rho^2 \omega^2}{2 \sin^2 a}$$

After the lapse of any time t an angle θ is generated such that $r = \rho e^{-\omega t \cot a}$ or $\rho e^{-\theta \cot a}$

At any subsequent period $\frac{m \rho^2 \omega^2 e^{-\omega t \cot a}}{2 \sin^2 a} = \frac{1}{2} I \frac{\omega^2 e^{-\omega t \cot a}}{\sin^2 a}$

$v r = \rho e^{-\omega t \cot a} = \frac{\sqrt{n}}{\sqrt{m}} \cdot \frac{r_1}{r} \cdot \rho e^{-\omega t \cot a}$ ~~more I can't prove~~ r

The energy remaining after an angle π has been described will be

$$\frac{m\rho_1^2\omega^2}{2\sin^2 a} = m\rho^2 e^{-2\pi\cot a}\frac{\omega^2}{2\sin^2 a}$$

So that the energy lost in overcoming friction is $\frac{m\rho^2\omega^2}{2\sin^2 a}\left(1-e^{-2\pi\cot a}\right)$

which will be the energy of the projectile at the outset of its second trajectory

or $\frac{m\rho^2\omega^2}{2\sin^2 a}\left(1-e^{-2\pi\cot a}\right) = \frac{m\rho_1^2\omega^2}{2\sin^2 a}$

Let $\frac{\rho}{\rho_1} = R^2$

Then $R^2 = \frac{1}{1-e^{-2\pi\cot a}}$

Since $\frac{\lambda}{\pi} = \cot a$ $= \frac{1}{1-e^{-2\lambda}}$

$$R^2(1-e^{-2\lambda}) = 1$$

$$\therefore R^2 - R^2e^{-2\lambda} = 1$$

$$e^{-2\lambda} = \frac{R^2-1}{R^2}$$

$$e^{-\lambda} = \frac{\sqrt{R^2-1}}{R}$$

$$\lambda = \log_e\frac{R}{\sqrt{R^2-1}}$$

Suppose that the elongation η is the first throw and that through the effect of damping the νth throw is $\frac{\eta}{R}$

where $R = \frac{1}{\sqrt{1-e^{-2\pi\cot a}}}$

Then $\lambda = \frac{1}{\sqrt{n}} \log_e \frac{1}{\sqrt{1-e^{-2n\cot\alpha}}} = \frac{1}{n} \log_e \sqrt{1-e^{-2n\cot\alpha}}$

but the rth throw would be after a throw of rn radians so that ρ would be

$$\rho_r = \rho e^{-rn\cot\alpha}$$

$$\therefore \quad \frac{\rho_r}{\rho} = e^{-rn\cot\alpha} = e^{-n\lambda}$$

$$\frac{\rho}{\rho_r} = e^{n\lambda} \quad \therefore \quad \lambda = \frac{1}{n} \log \frac{\rho}{\rho_r}$$

Where $R = (1 - e^{-2n\cot\alpha})^{-\frac{1}{2}}$

$\therefore \log R = -\frac{1}{2} \log (1 - e^{-2n\cot\alpha})$

$\log R^2 - 1 = +2n\cot\alpha$

$\therefore \log$

An additional method of proof.

The initial energy possessed by the projectile at the ∞ is $\frac{mv^2}{2} = \frac{mp^2\omega^2}{2\sin^2\alpha}$

The work done by the projectile against a retarding force of $2mkv$ through an indefinitely small space ds is

$$2mkvds = 2mk\frac{vrd\theta}{\sin\alpha} = \frac{2m\omega\cot\alpha\,\omega r^2 d\theta}{\sin\alpha}$$

$$= 2m\omega^2\frac{\cot\alpha}{\sin^2\alpha}r^2 d\theta \qquad \text{But } r = pe^{-\theta\cot\alpha}$$

$$\therefore r^2 = p^2 e^{-2\theta\cot\alpha}$$

$$\therefore \text{Wk} = 2m\omega^2\frac{\cot\alpha}{\sin^2\alpha}p^2\int_0^\infty e^{-2\theta\cot\alpha}d\theta = 2m\omega^2\frac{\cot\alpha}{\sin^2\alpha}p^2\left(\frac{e^{-2\cot\theta}-1}{-2\cot\alpha}\right)$$

$$\therefore = \frac{mp^2\omega^2}{\sin^2\alpha}\left(1-e^{-2\pi\cot\alpha}\right)$$

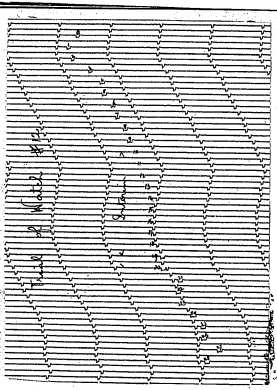
The work done upon the projectile by the attractive force μm through an indefinitely small space ds of its path is $ds\cos\alpha\,\mu m$

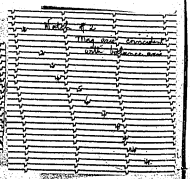
$$= \frac{m\cos\alpha}{\sin^2\alpha}\omega^2 r^2 d\theta \therefore W = m\frac{\cot\alpha}{\sin^2\alpha}\omega^2 p^2\int_0^\infty e^{-2\theta\cot\alpha}d\theta$$

$$= \frac{m\cot\alpha}{\sin^2\alpha}\omega^2 p^2\left(\frac{1-e^{-2\pi\cot\alpha}}{2\cot\alpha}\right)$$

$$= \frac{m}{2}\frac{\omega^2 p^2}{\sin^2\alpha}\left(1-e^{-2\pi\cot\alpha}\right)$$

so that the energy lost will be the difference of these quantities or $\frac{m}{2}\frac{\omega^2 p^2}{\sin^2\alpha}\left(1-e^{-2\pi\cot\alpha}\right)$



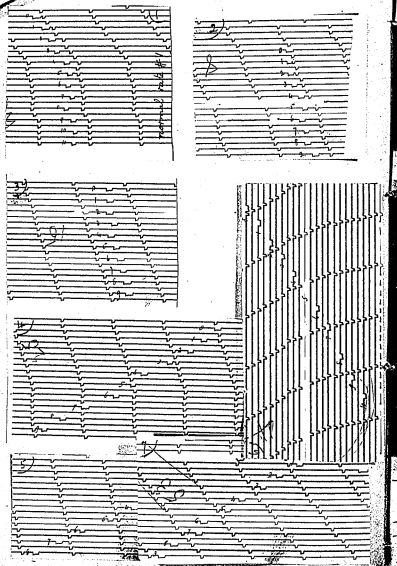


Monday 27th August

Paillard Watch #12 was placed with its dial up in a powerful magnetic field the magnetic axis coinciding practically with the balance wheel axis. A run of nine minutes failed to show any decided change in rate under these circumstances. If anything there is a losing rate. This rate amounts to 0·6 secs in 28 hours = 1·2 per hr = 29 per diem

Paillard Watch #2 was placed under the same circumstances in the same field. The rate is evidently losing about 2·2 secs in 11 mins = 12 secs per hour = 288 per diem.

In second run was with the magnetic axis eccentric to the balance wheel axis of −2·8 secs in 7 mins = ·25 secs per hour = 6·00 per diem



In the afternoon exposed Watch #3 to the field but it stopped continually.
Took the following result with #1

1st trial Watch compared with chronograph without magnetic field. Diagram #1
Gained in 11 mins 0.15 secs.
at rate of = rate of + 0.82" per hour
= - - + 19 - diem.

2nd trial In field magnetic and wheel axes almost coincident. Def. on Ring ten. 8°
Field throw 38, 35.5 Mean 36.8 = 1480 C.G.S. u.
Watch gained (Diagram #2) 13.4 secs in 9 mins
= rate of + 2.2 secs per hour
+ 52.8 secs per diem

3rd trial In field unaltered condition Def. 15°
Field throw 60.5 59.0 Mean 59.75 = 2400 C.G.S F
Watch gained 0.4 (Diagram #3) in 9 mins
= rate of + 2.67 secs. per hour
+ 64 secs. per diem

4th trial Def. 25° Field throw 89 86 86 Mean 87
= 3500 C.G.S. Field.
Watch gained 3.9 secs (Diagram #4) in 9 mins.
= rate + 26 secs. per hours
+ 624 - - diem.

5th trial Def. 35.15 to 36.15° Field throw 105 107 Mean 107.5
= 4300 C.G.S Field.
Watch gained (Diagram #5) 16.1 secs in 8 mins.
= rate + 20.75 secs. per hour.
+ 738 - - - diem.

Omit 6th trial Def. 46° Field throw 118 120 118 Mean 118.3
= 4790 C.G.S Field. (Diagram #6) N.B. This was first trial in order and results were afterwards omitted
Watch gained 4.6 secs in 10 mins
= rate of + 27.6 secs per hour.

7th trial Def. 53 to 53.5° Field throw 123, 122 123 Mean 122.5
= 4930 C.G.S Field (Diagram #7)
Watch gained 4.35 sec in 7 mins = 37 secs per hr = 696 secs per diem

Monday 27th August
Physiological Experiment

#19 Yellow spitzbergen dog. Weight 37½
Length 32
Height 18
Res: 200,000 ω
wetted bandages thoroughly) and repeated
test. resistance still as high.
Resp: invisible.

20.48 Continuous Current
Cardew voltmeter 52° = 76° × 4 = 304 volt
Contact for 30 secs:
On making contact dog leaped from box.
Howled and struggled almost all time.
After current dog not apparently hurt.
Resp: slow but not measurable.
Res: after shock 40,000 ω.

21.15 Cardew Voltmeter 95°.
Alternating Current direct from machine
= 110 × 0.9 = 100 volt.
Contact for 65 second. Dog silent
when current put on but howled
once at about half period.
Dog apparently considerably depressed but
not seriously hurt.

30 Cardew voltmeter 57° = 80 × 7 = 560 × 0.90
Contact for 30 second. During that
time the dog was silent and moaned
the head and body slowly falling. No struggle.
Dog dead when current removed. Res: after death 4000

Chart in
Envelope
N-880610

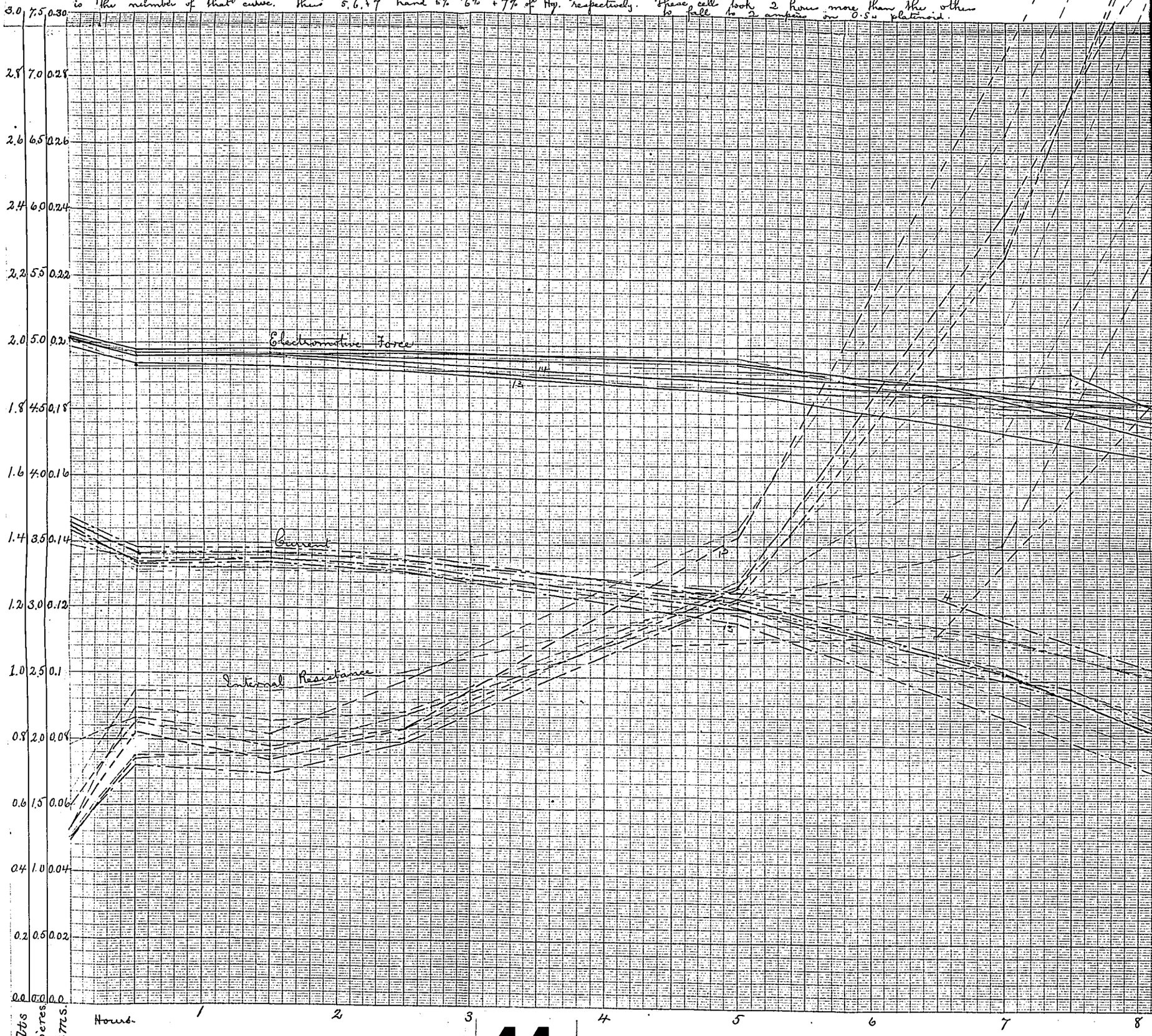
120 2nd Dog Small brown ~~wh~~ mongrel.

Weight 12½
Length about 17
Height about 10.
Resistance 1000
∴ Resp: could not be detected

22.00
Alternating Current without converter
usual speed of reversal (300 per sec).
Voltmeter 62° = 85° × 7 = 595 × 9 = 535.5 volts
Contact 1½ secs: as closely as could be judged
Dog uttered no sound. Ammeter about 0.38
(not reliable) After current removed gave
few convulsive gasps and died very quickly
Res: after death 26.00

Curves of 10 Grenet cells set up with same solution
viz 8.33 % American Chromic acid, 25.0 % Commercial Sulphuric Acid and 66.7 % Water
but with zincs made up with varying % of Mercury in their composition
The percentage of mercury in the zinc of the cell represented by any of these curves
is the number of that curve. Thus 5, 6, + 7 hand 5% 6% + 7% of Hg. respectively. These cells took 2 hours more than the others
to fall to 2 amperes on 0.5 ω platinoid.

27th July 1888



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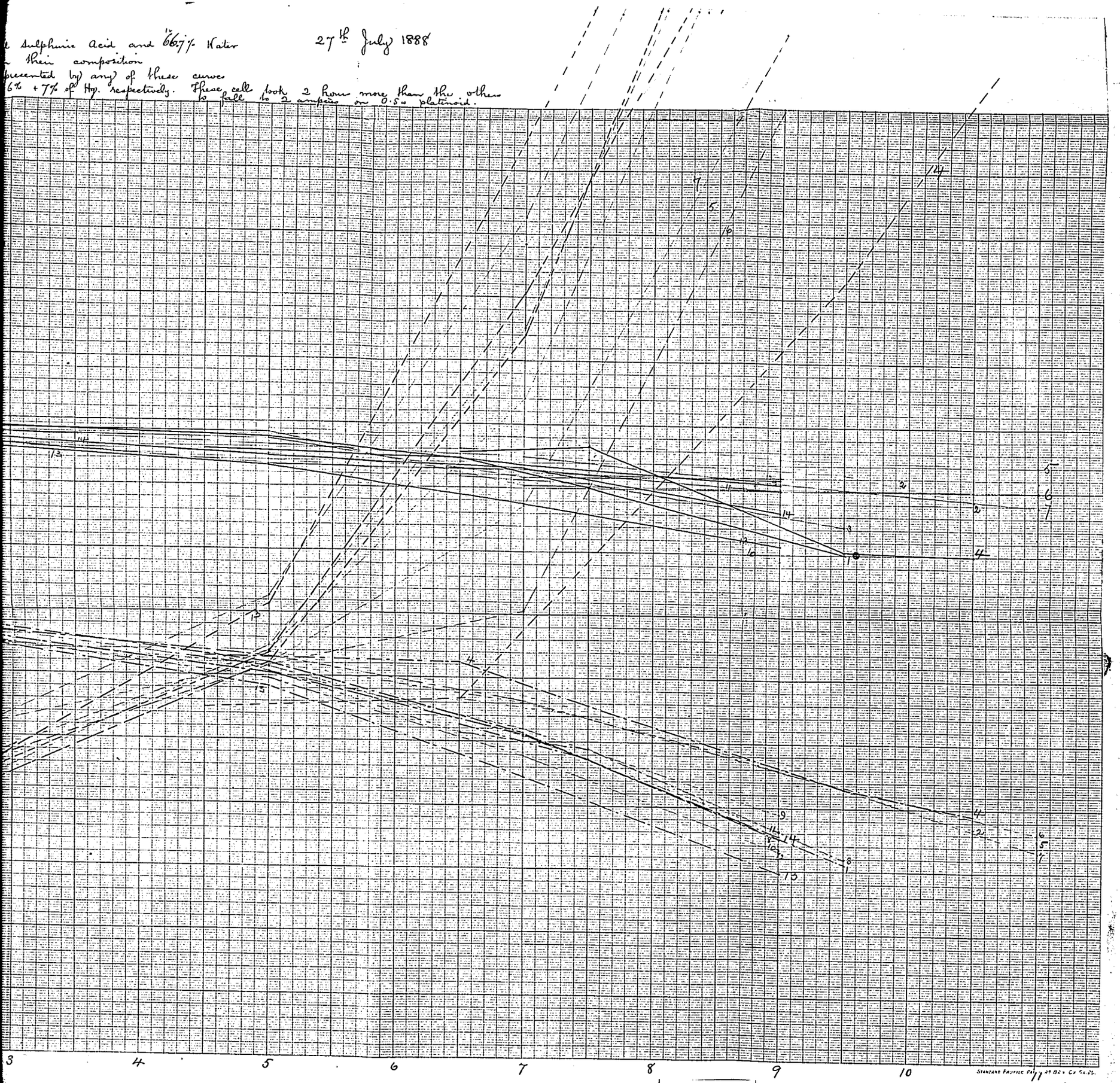
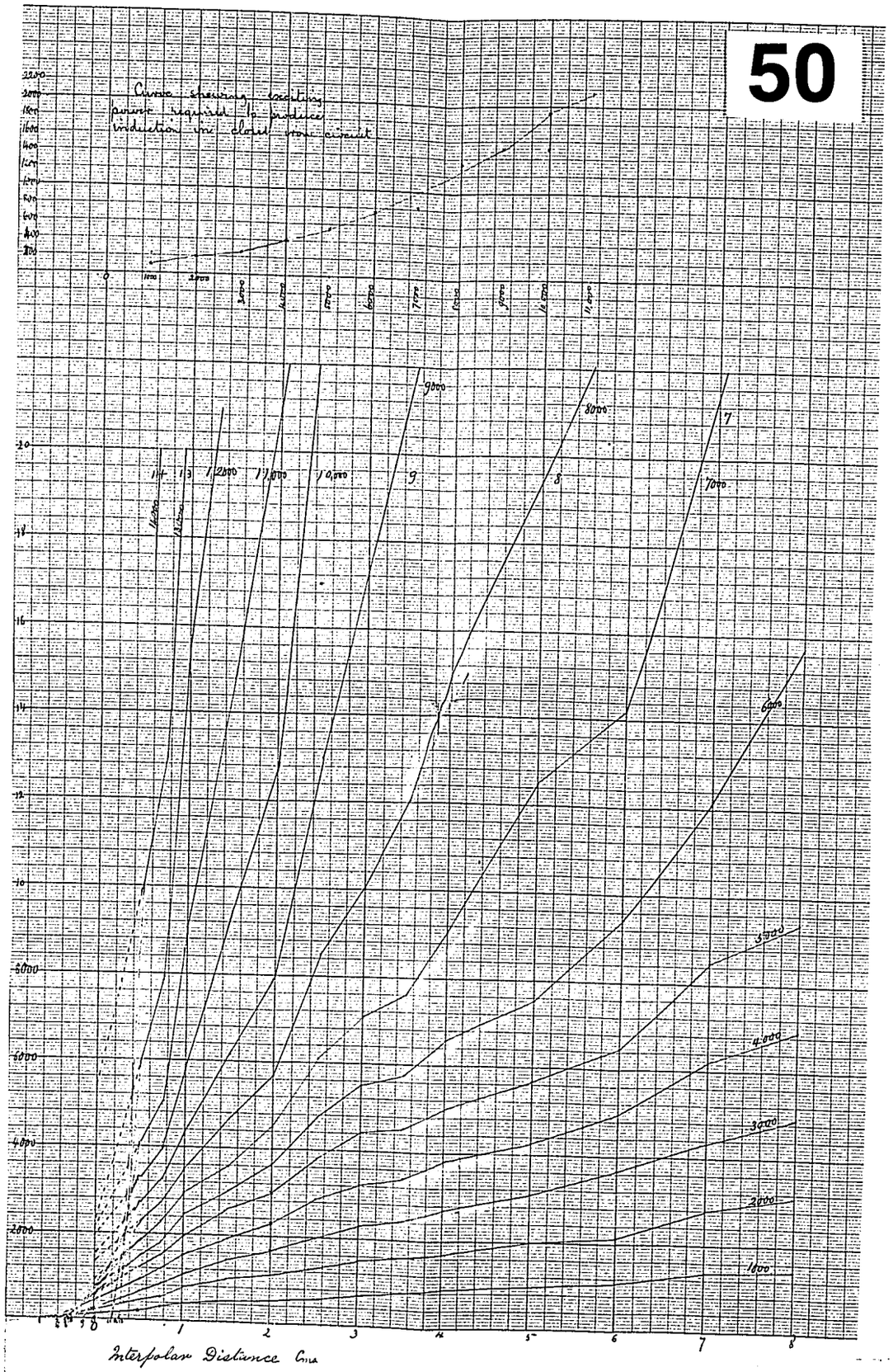
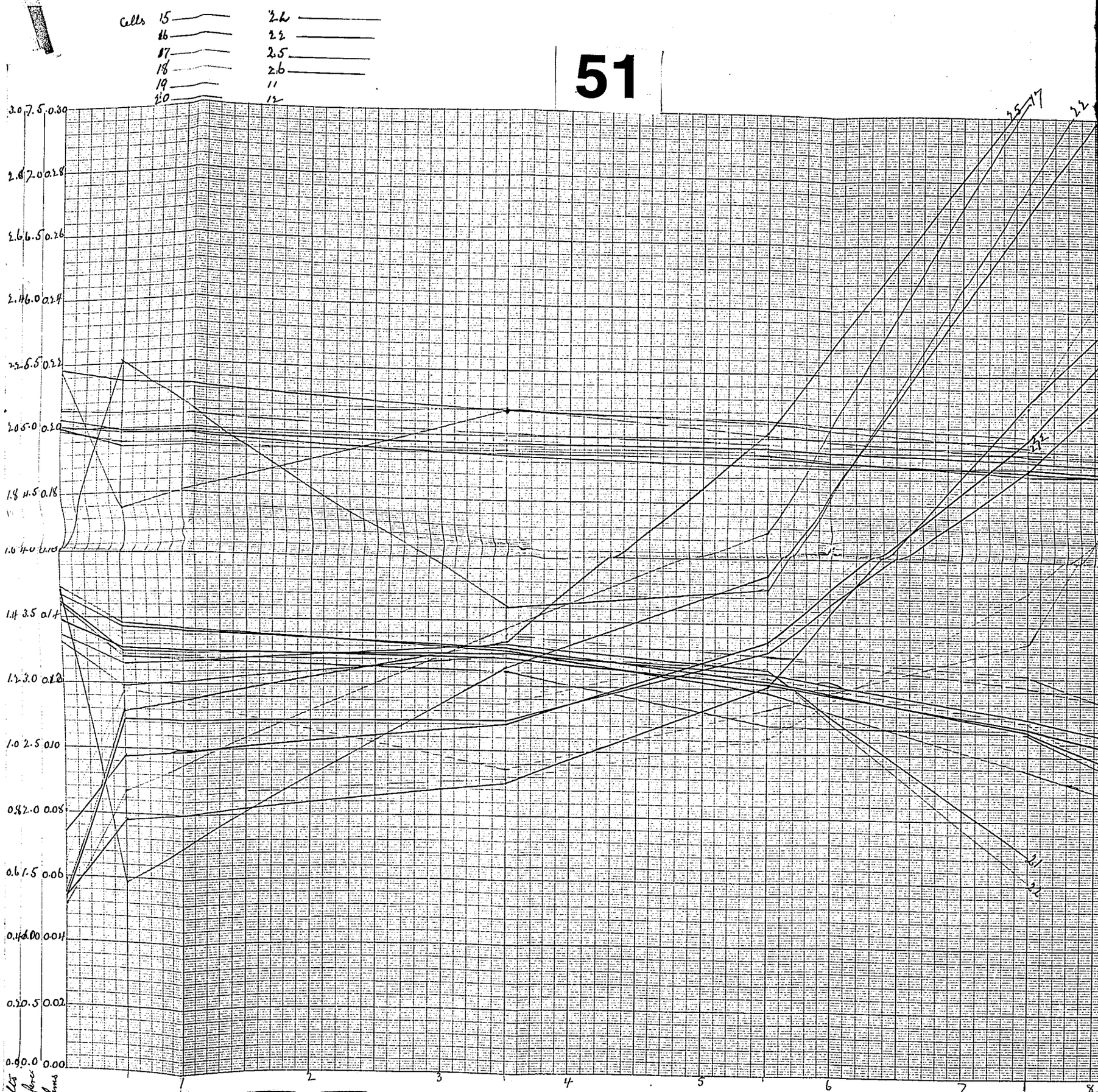
e Sulphuric Acid and 66.7% Water 27th July 1888
n their composition
presented by any of these curves
6% + 7% of Hyp. respectively. These call took 2 hours more than the others
to fall to 2 amperes on 0.5 in platinoid.




Curve showing exciting power required to produce induction in cloud wire circuit
Interpolar Distance Cms


Cells 15
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17
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26
11
12
3.0 7.5 0.30
2.8 7.0 0.28
2.6 6.5 0.26
2.4 6.0 0.24
2.2 5.5 0.22
2.0 5.0 0.20
1.8 4.5 0.18
1.6 4.0 0.16
1.4 3.5 0.14
1.2 3.0 0.12
1.0 2.5 0.10
0.8 2.0 0.08
0.6 1.5 0.06
0.4 1.00 0.04
0.2 0.5 0.02
0.0 0.0 0.00
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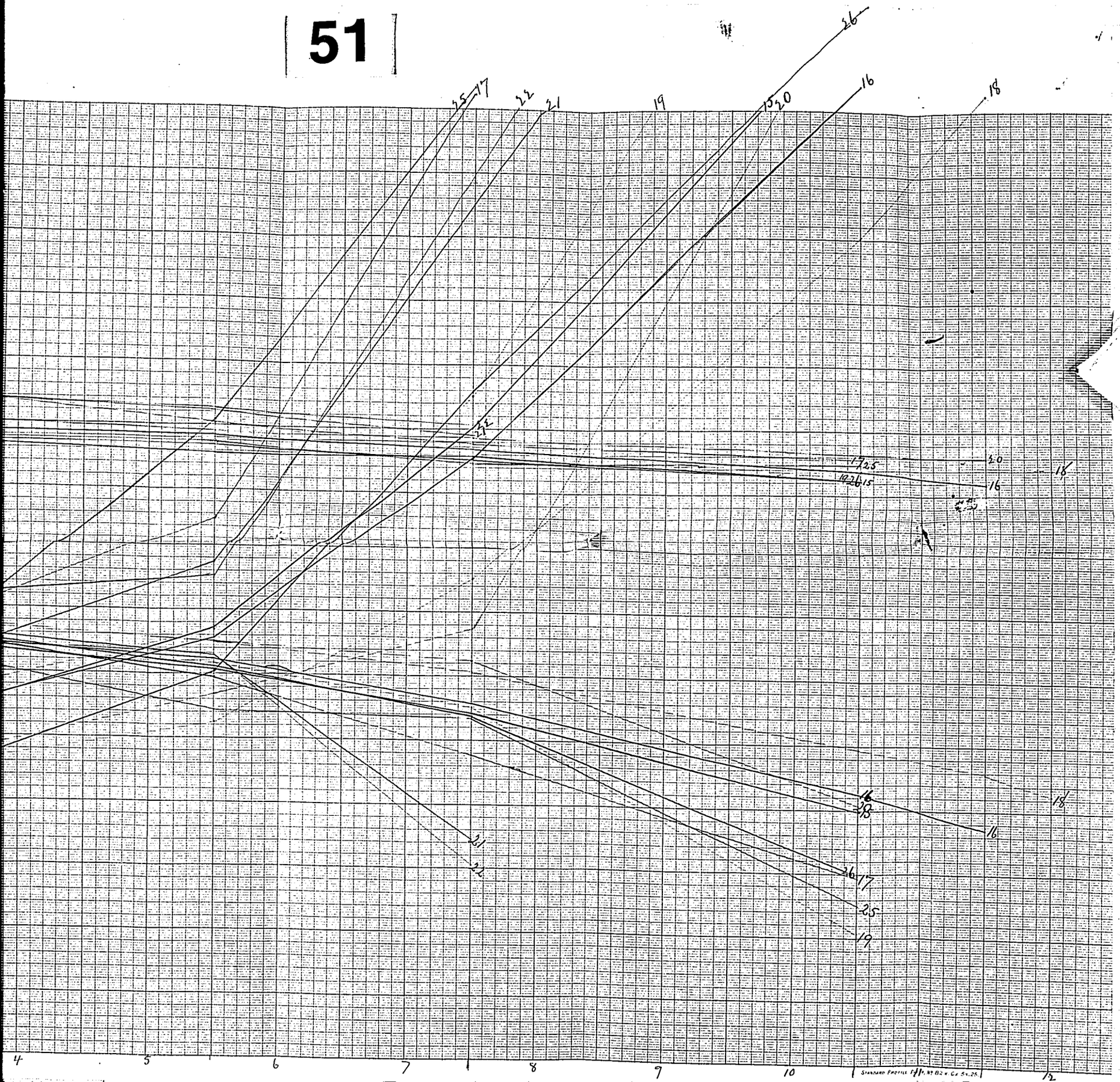

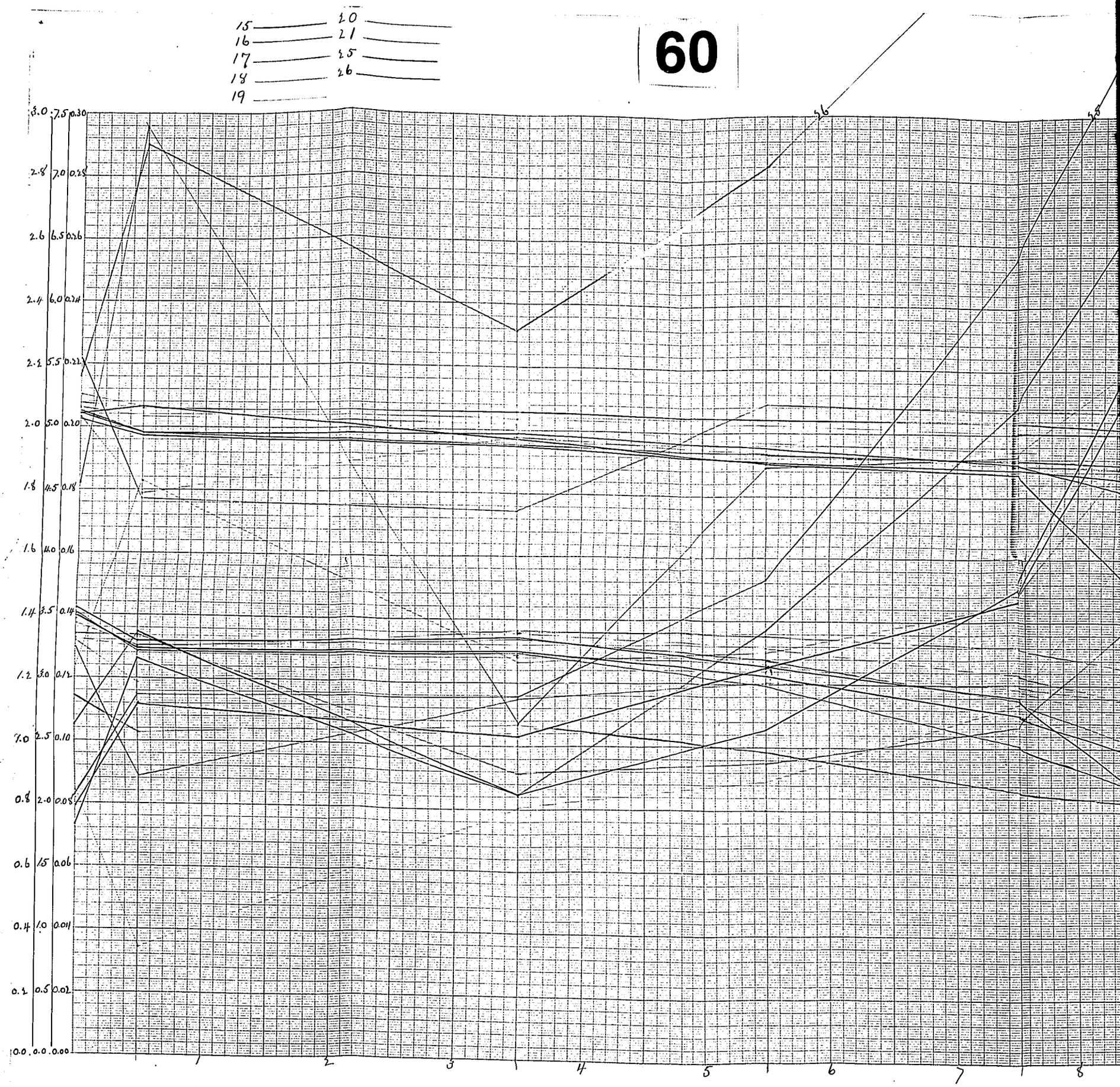
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2.4 6.0 0.24
2.2 5.5 0.22
2.0 5.0 0.20
1.8 4.5 0.18
1.6 4.0 0.16
1.4 3.5 0.14
1.2 3.0 0.12
1.0 2.5 0.10
0.8 2.0 0.08
0.6 1.5 0.06
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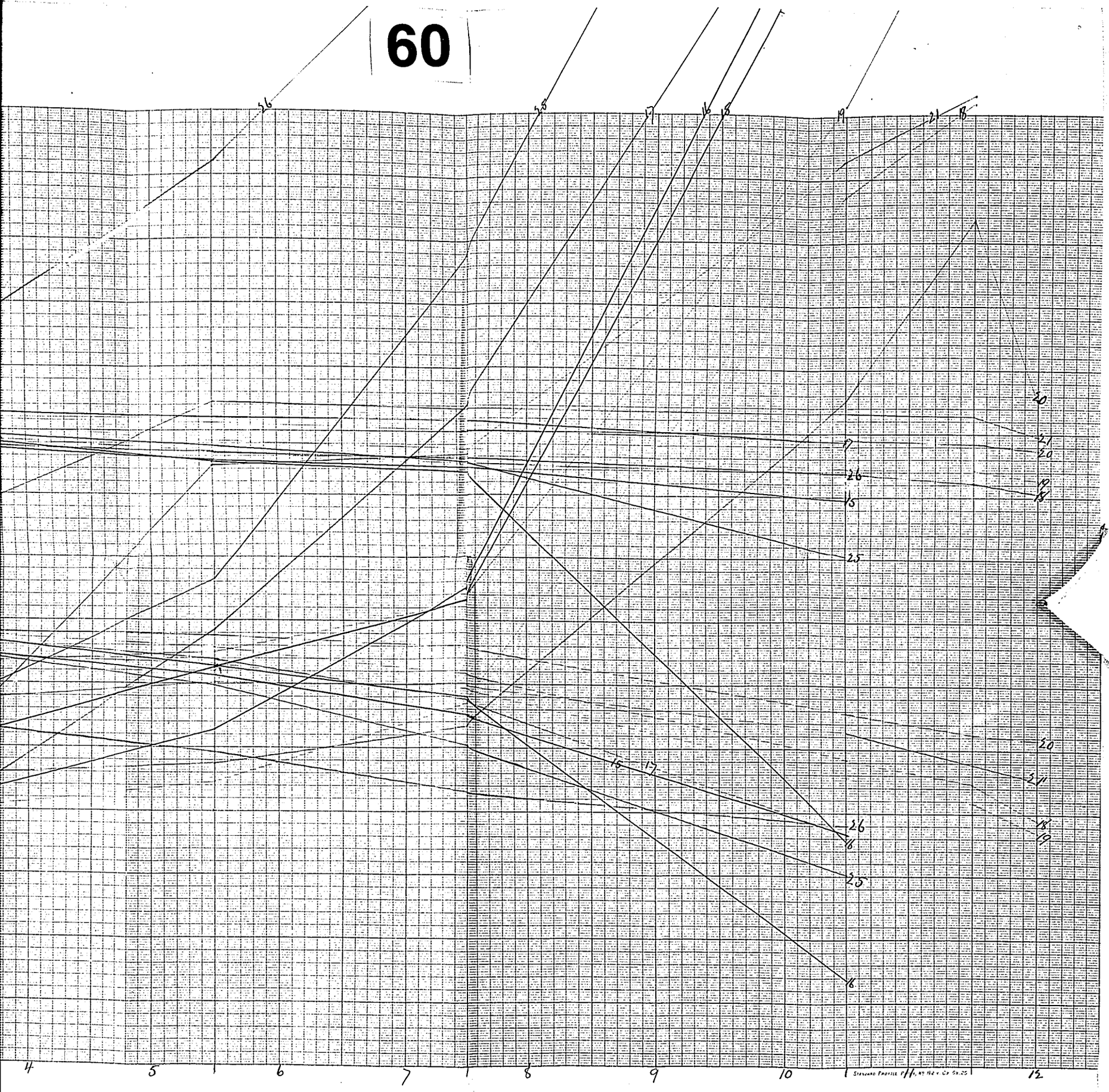
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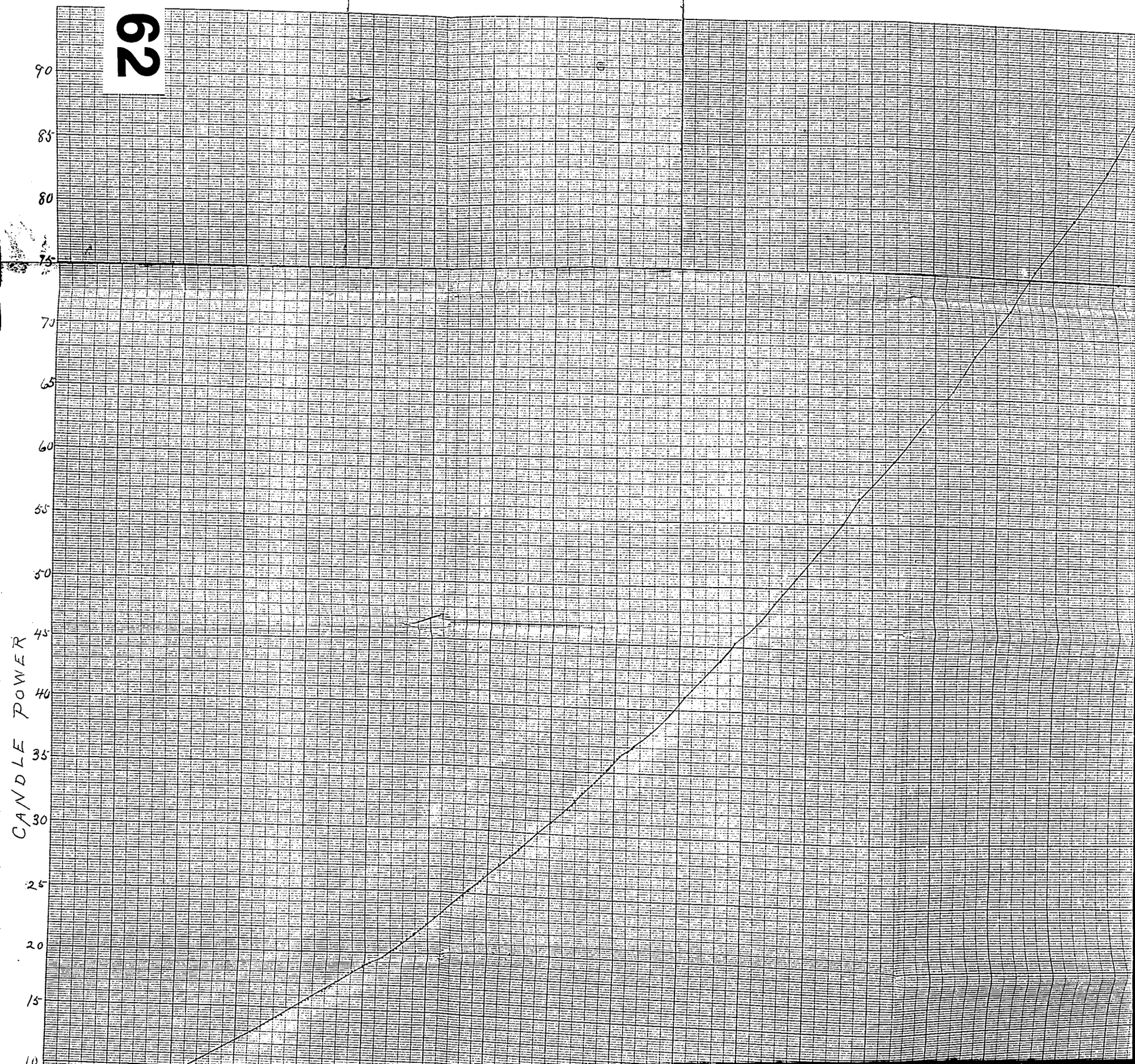

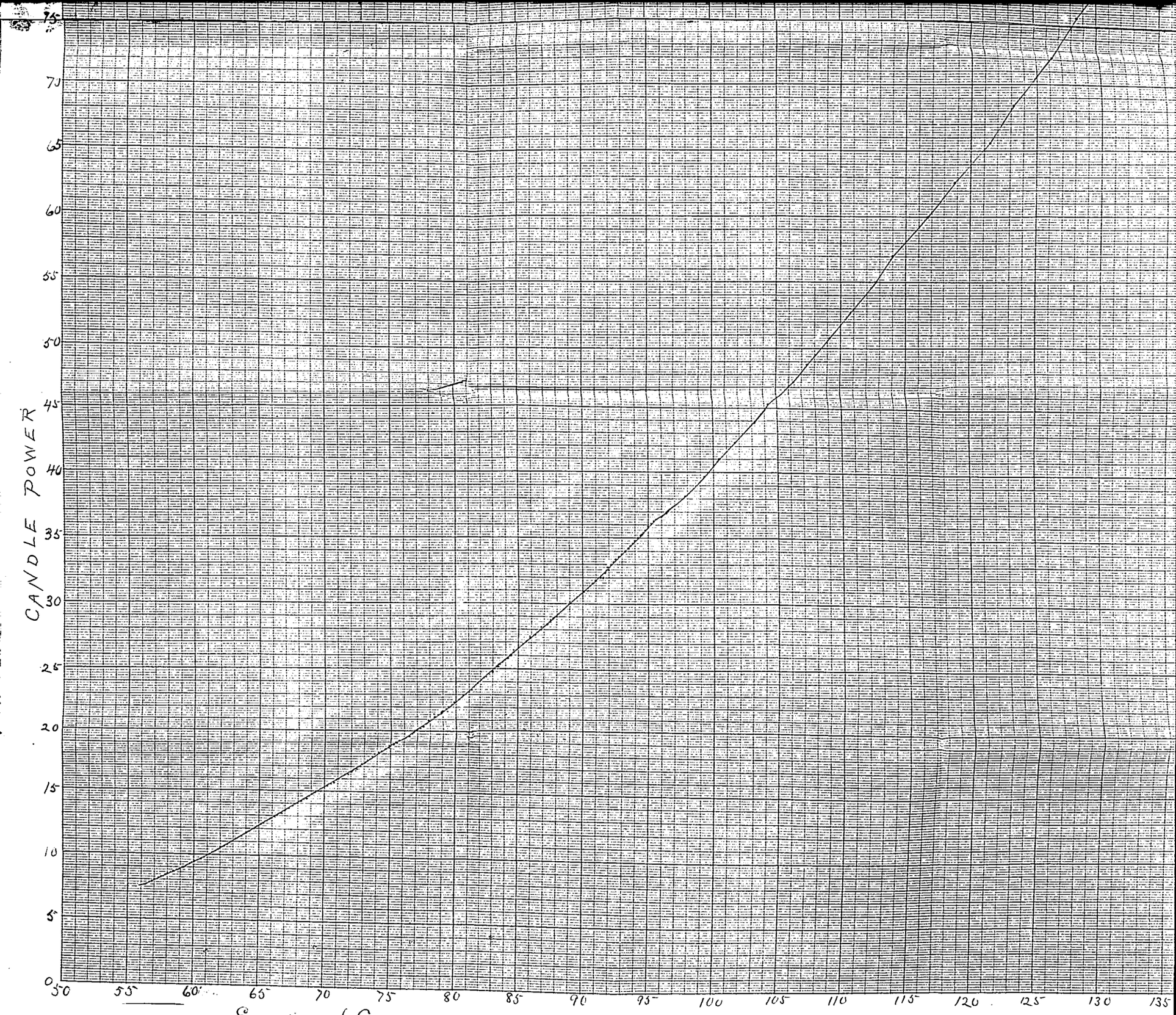

Equation of Curve
$y = .0062x^2 - .217x.$

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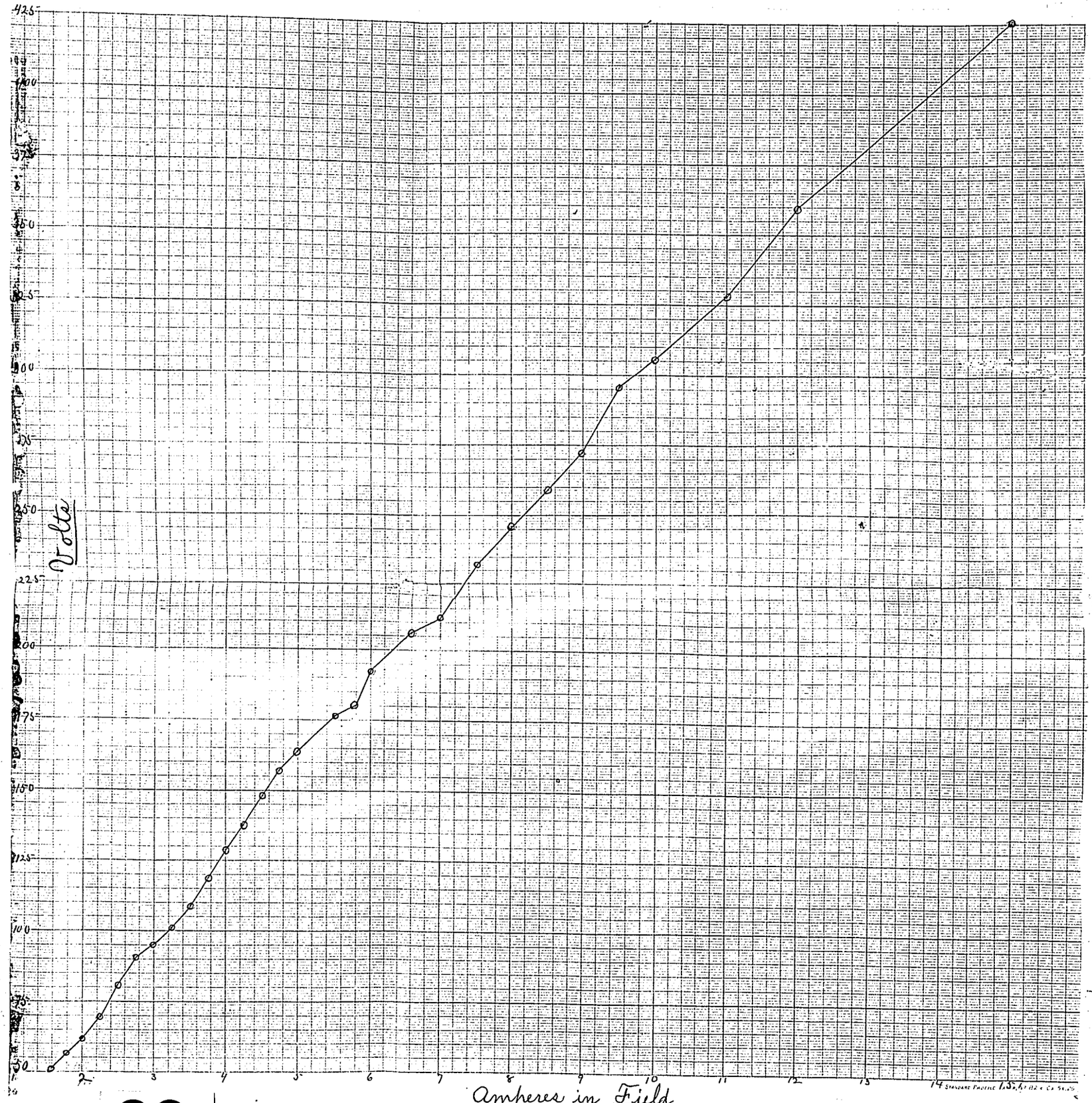

Characteristic Curve
Siemens Alternating Machine.